# Observations of SPS e-cloud instability with exponential pickup

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# Beam conditions

In 2008 a measurement and simulation campaign has been carried out to address these questions.
During summer there were two occasions to perform the measurements:

- In June during the so called "scrubbing run"
- In August in a dedicated machine development (MD) time.

The beam under study is the nominal LHC beam ($1.2 \cdot 10^{11}$ ppb spaced by 25ns in 4 trains of 72 bunches).
In nominal conditions the beam is stable, but the LHC performance development relies on 4 times the currents. In order to simulate this conditions, several measure has been taken:

- a fifth batch of 72 bunches is injected in order to increase the e-cloud density (June);
- chromaticity (which is an instability dumping mechanism) is lowered to minimal level (June, August);
- longitudinal emittance has been artificially reduced using quadrupolar oscillation (August);

# Measurement setup

The aim is too look at the vertical deformations of the bunch density (normally Gaussian in the three dimensions).
We used a strip-line pickup optimized for large bandwidth (exponential pickup) has been used to measure the longitudinal profile density and the vertical displacement.
The signal of the strip line is brought to the surface through a 100m coaxial cables.
The signal at the surface are acquired by a fast digital scope.

# Limitation of the measurements

The measurements are not easy for several reason:

- machine reproducibility: current and emittance, vary bunch by bunch and cycle by cycle. Chromaticity variations are relevant due the low set value.
- not enough high current (in particular after the machine is scrubbed) to provoke a strong instability.
- high bandwidth is difficult to be preserved in all the acquisition chain: pickup (no measurements a high frequency, , hybrids, cable).
- information on the vertical displacement is entangled with the longitudinal distribution.

# Bunch profile

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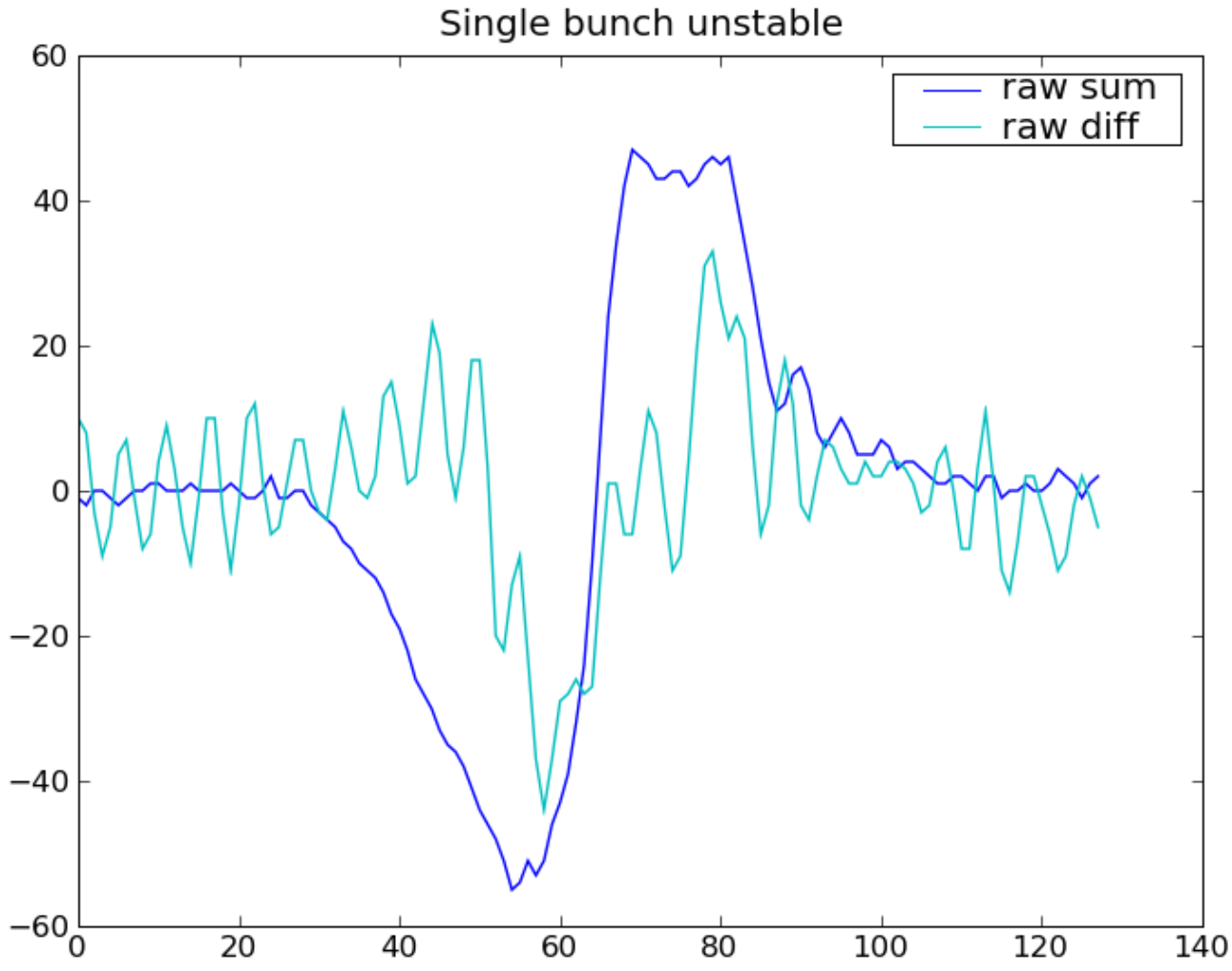
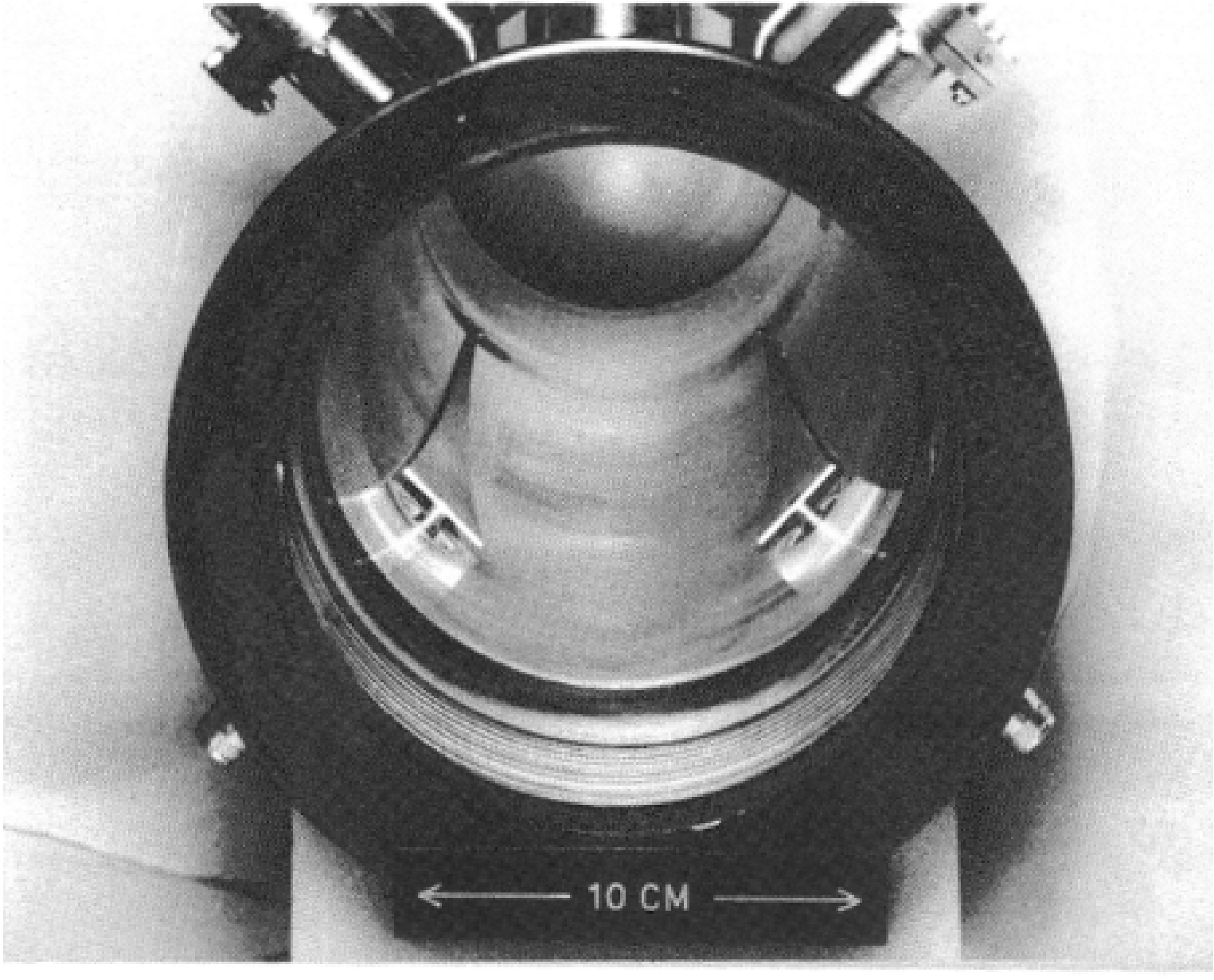


# Exponential wide band pickup



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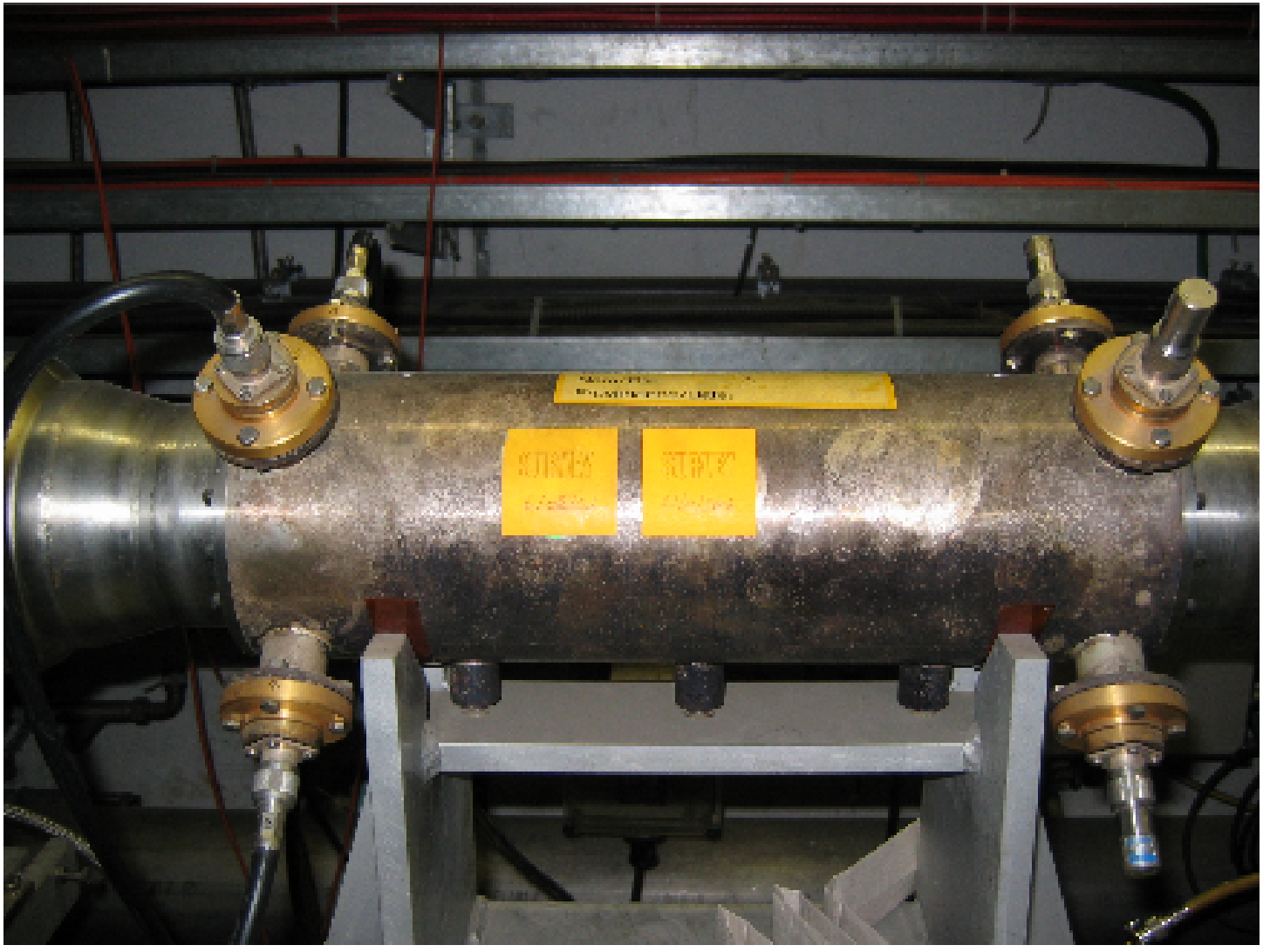
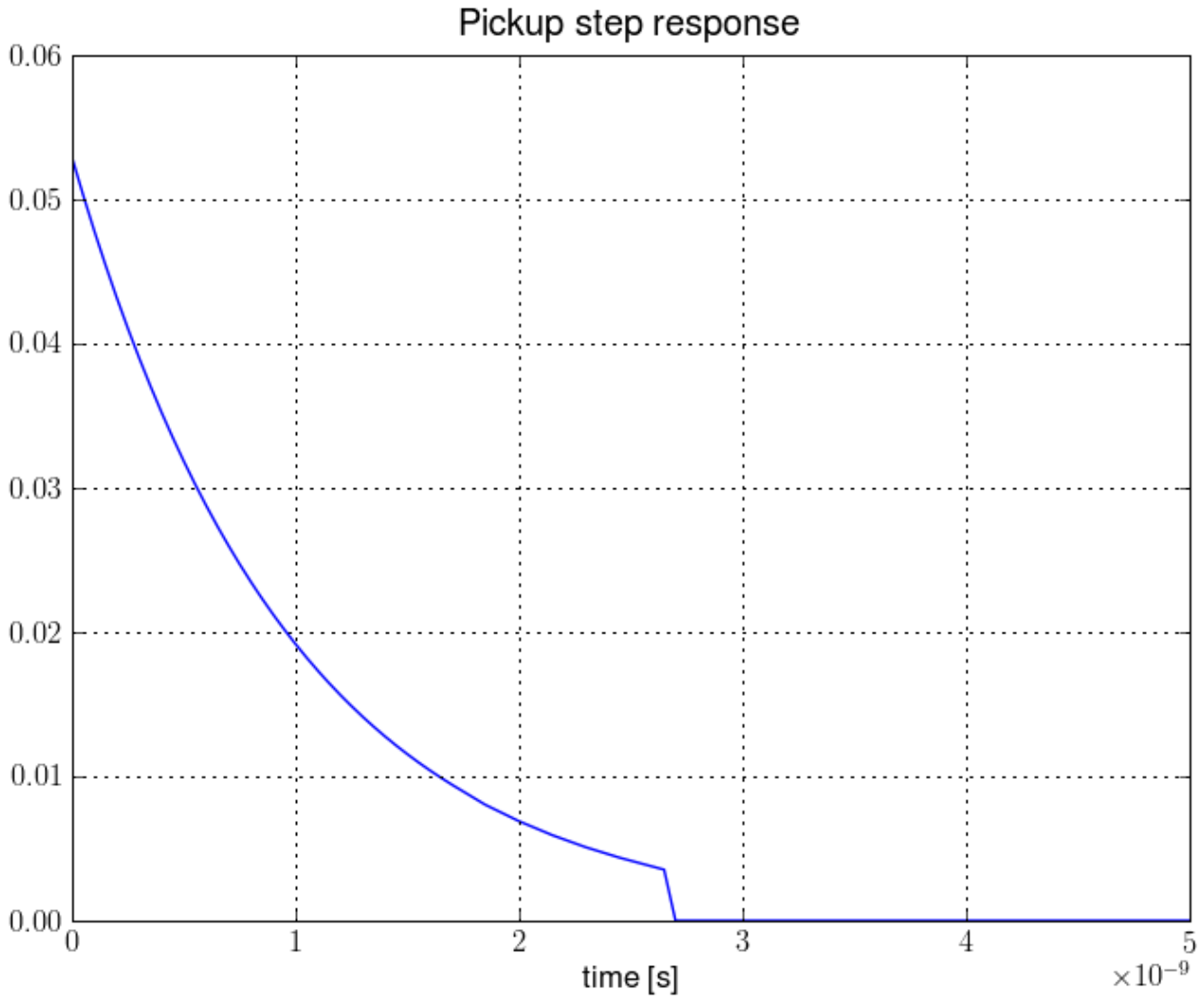


# Pickup effect



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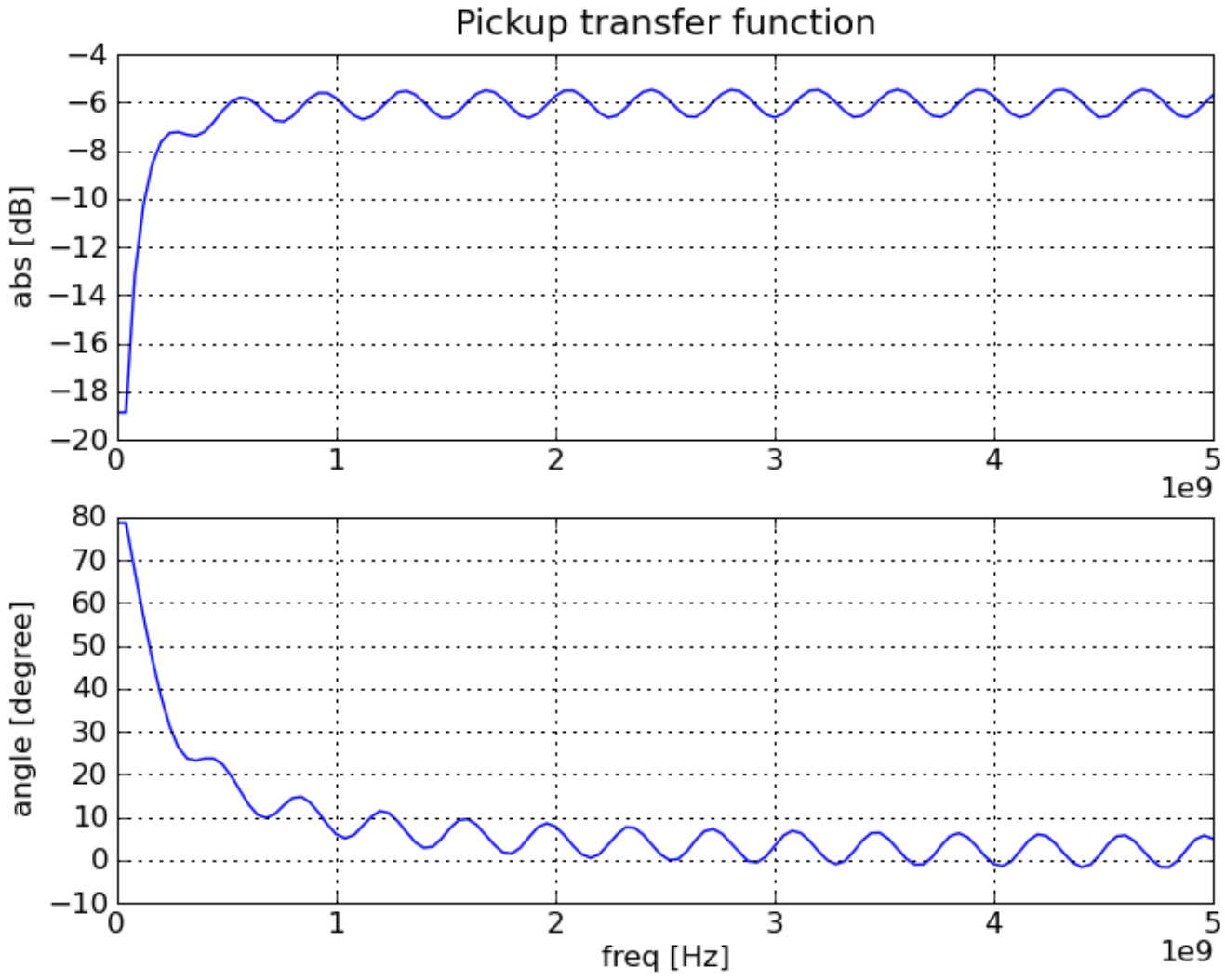
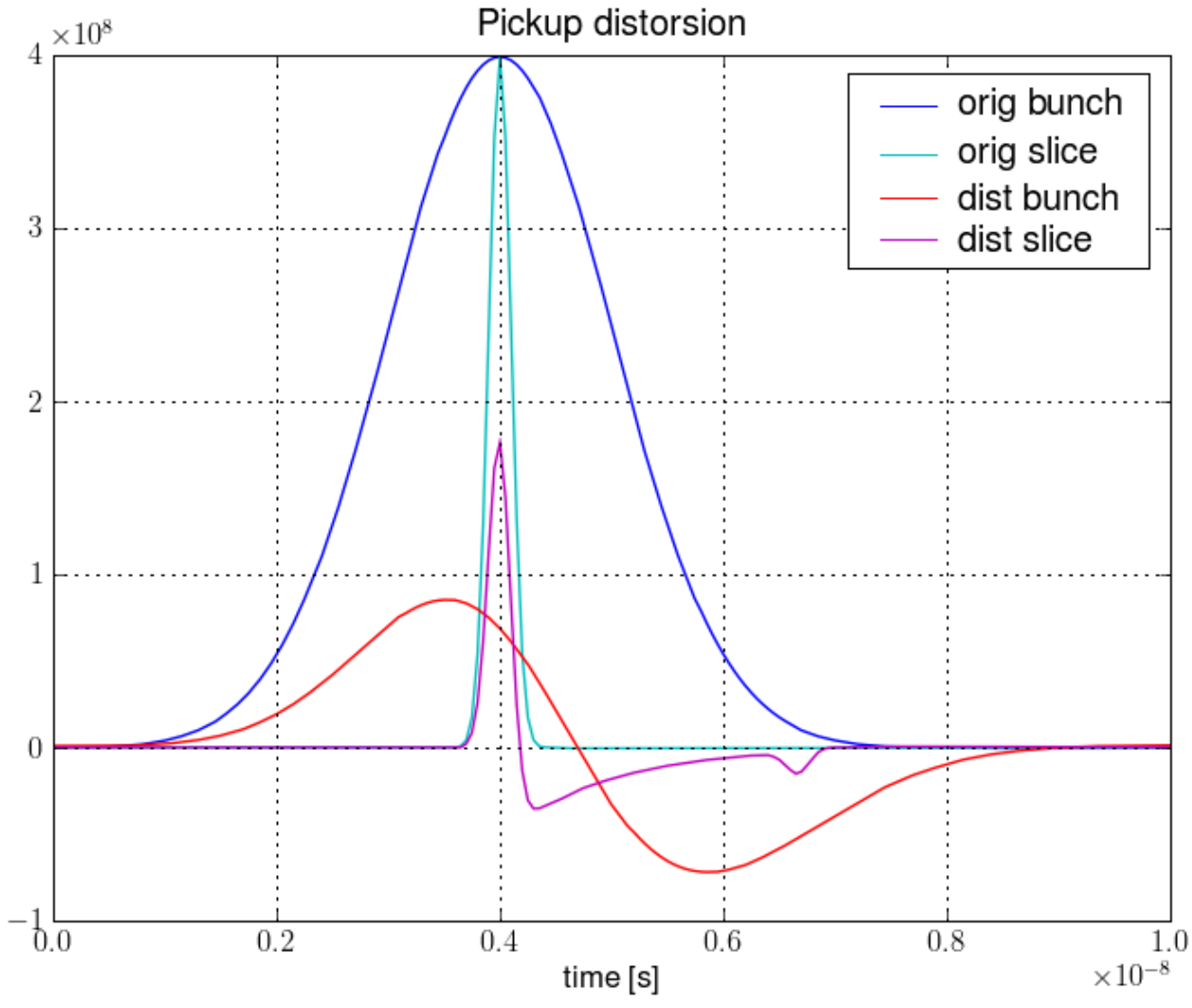


# Pickup effect



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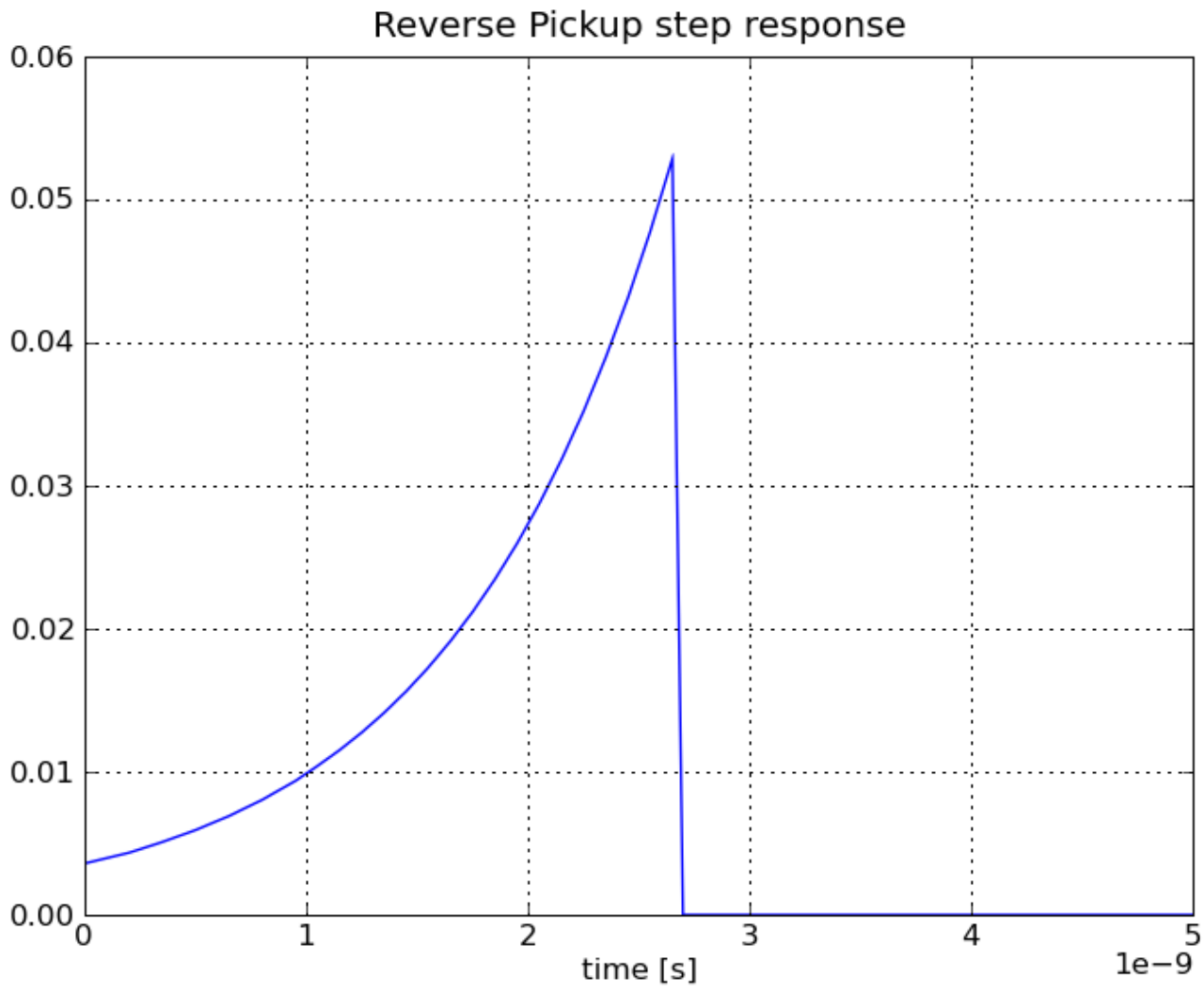
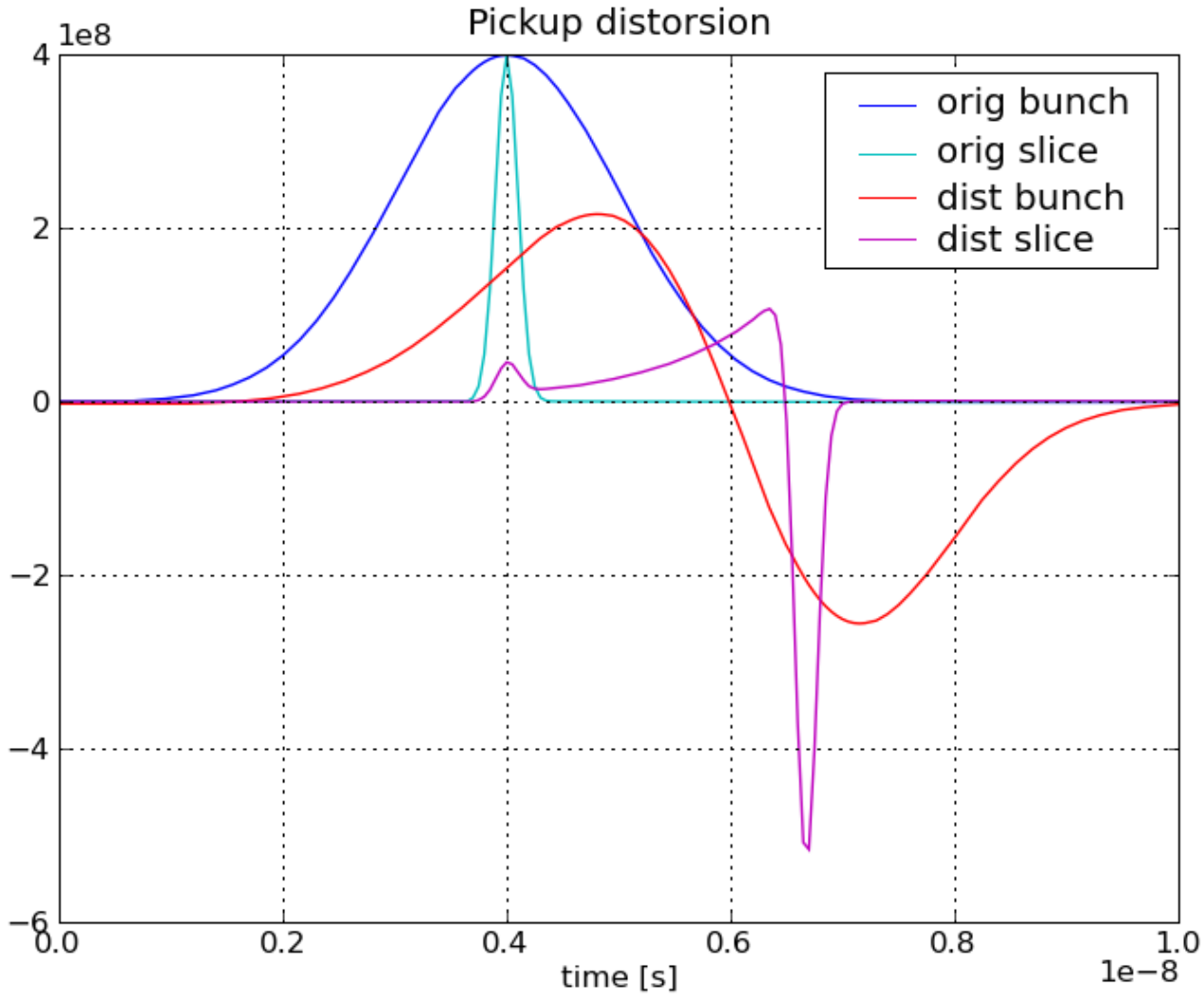
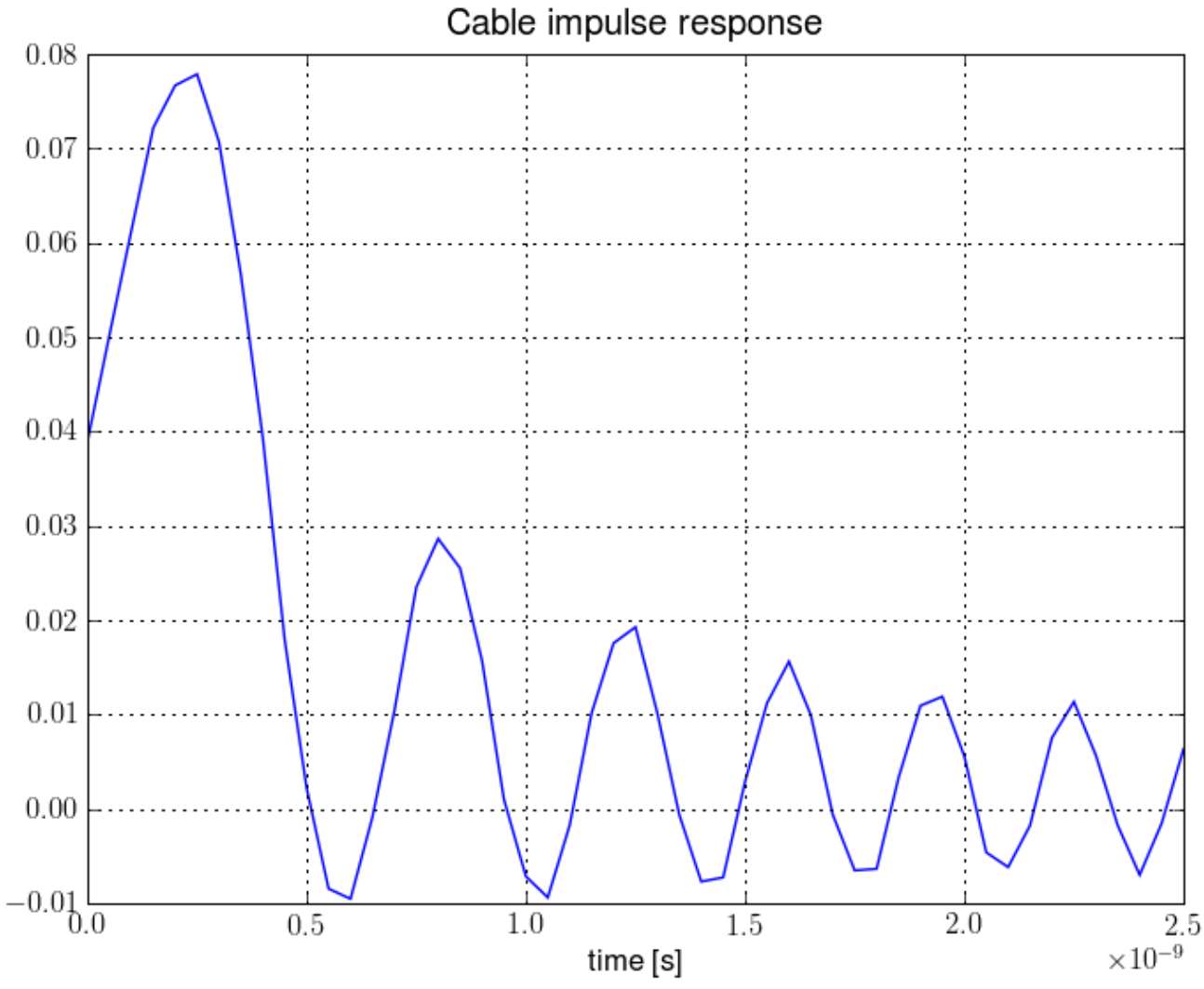


# Pickup effect



# Cable effect



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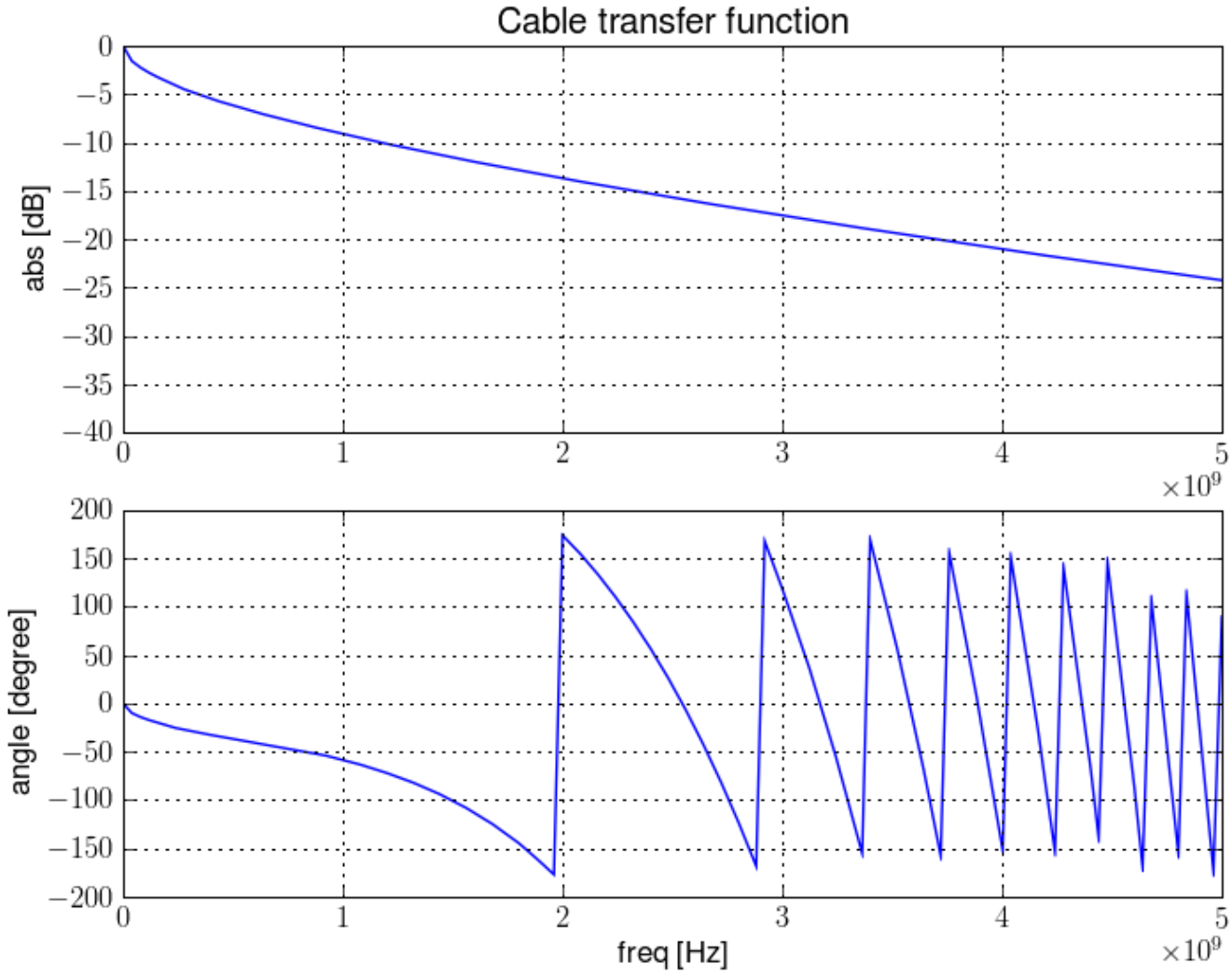

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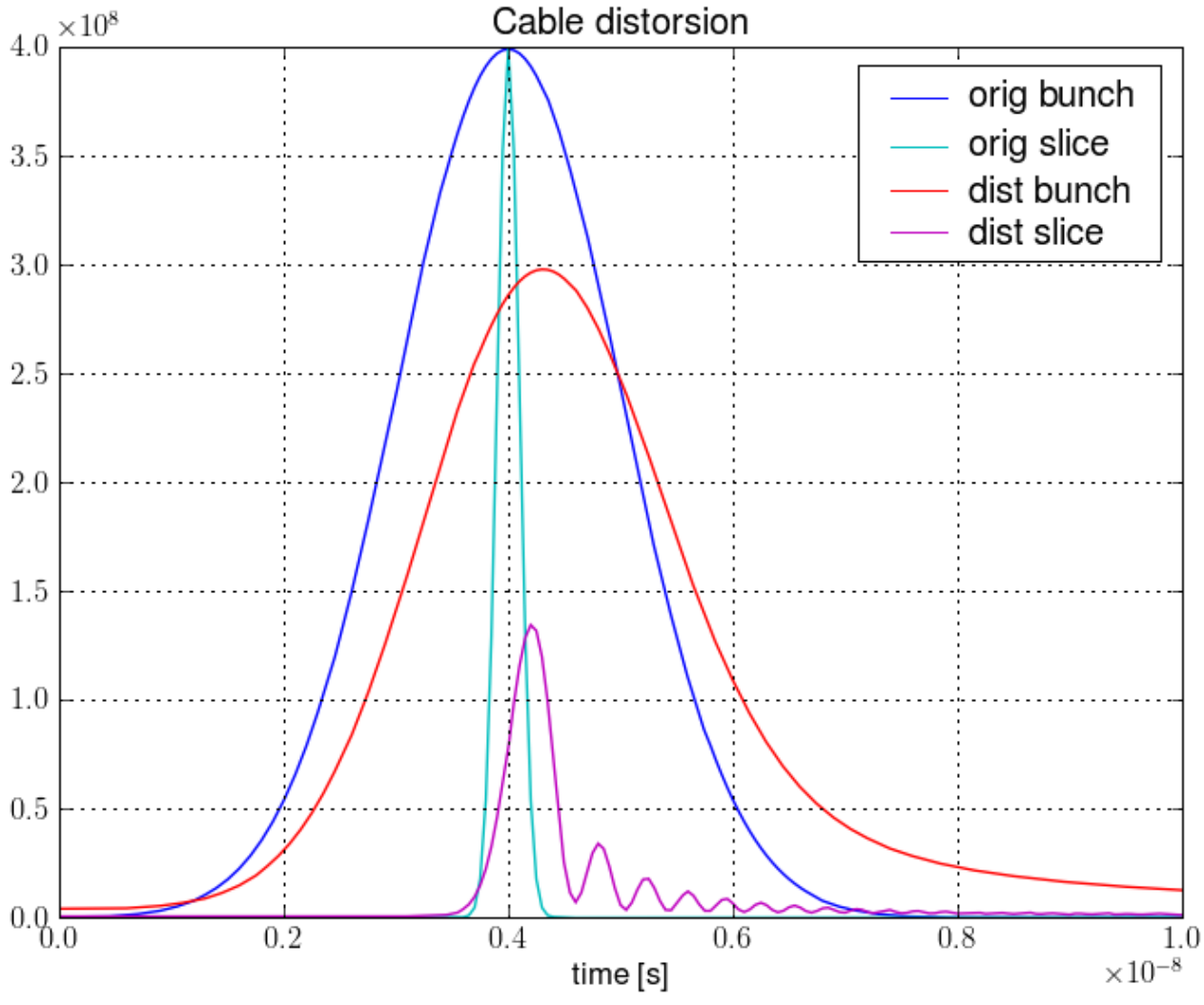
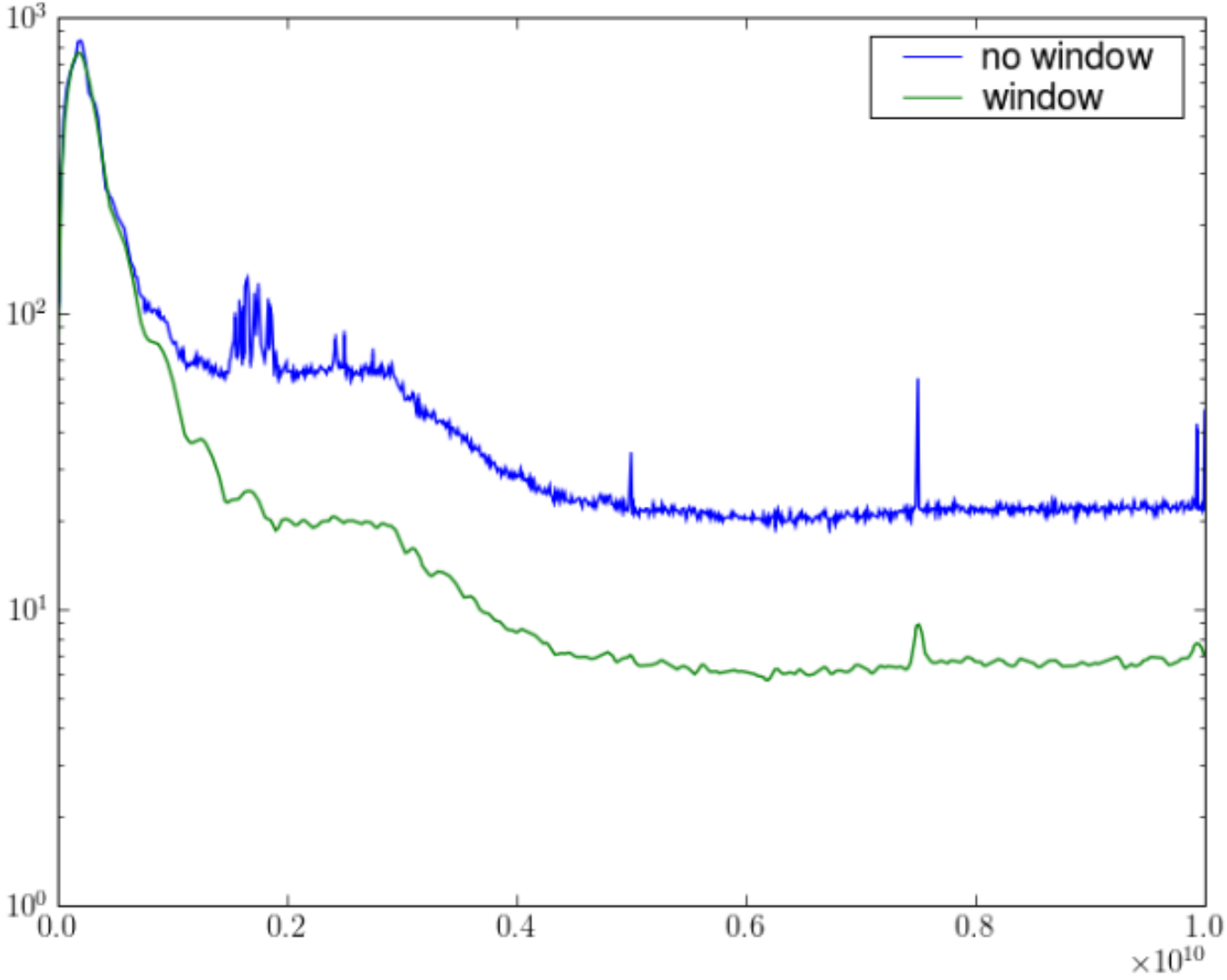


# Propagating modes




freq [Hz]

# Processing raw data

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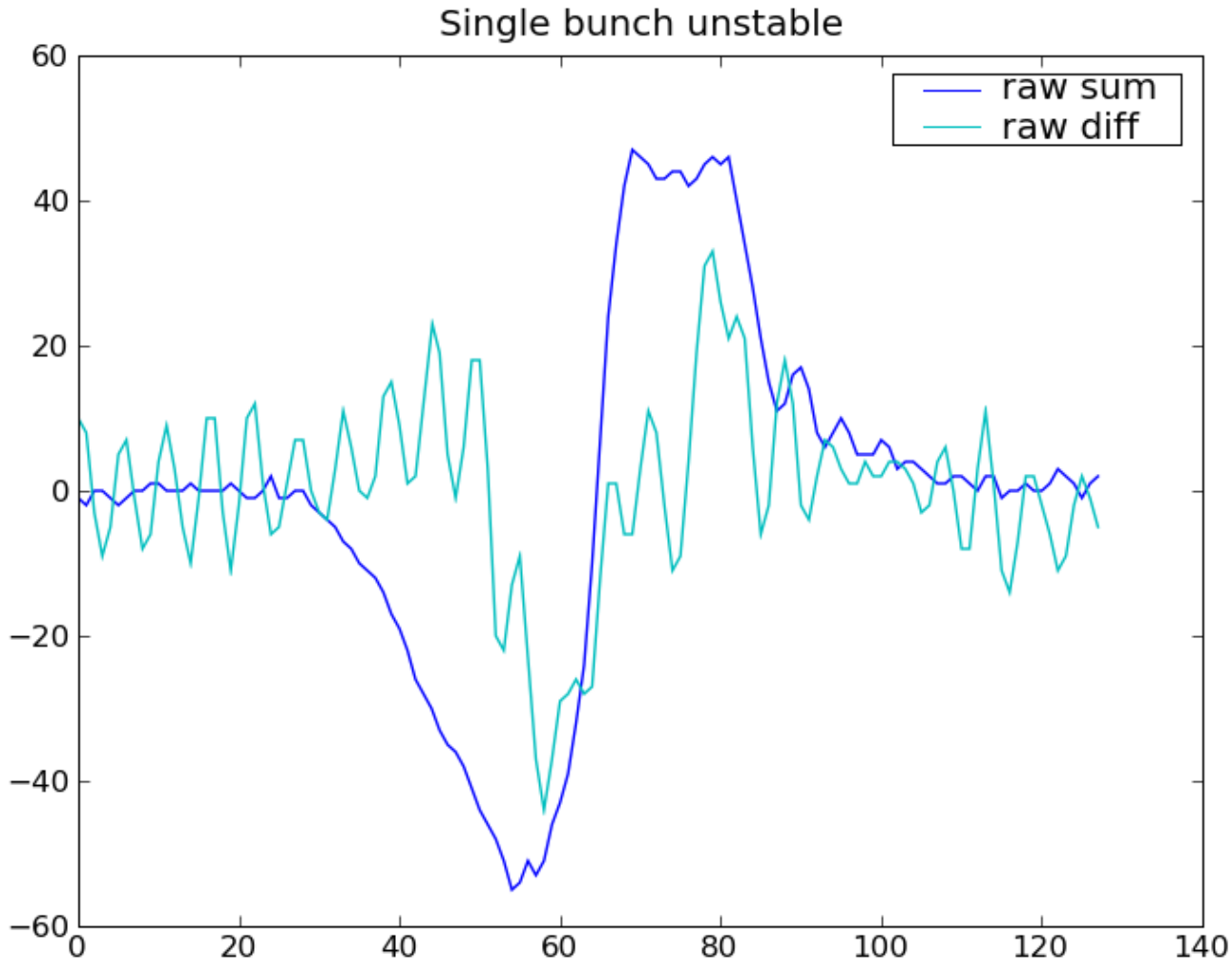

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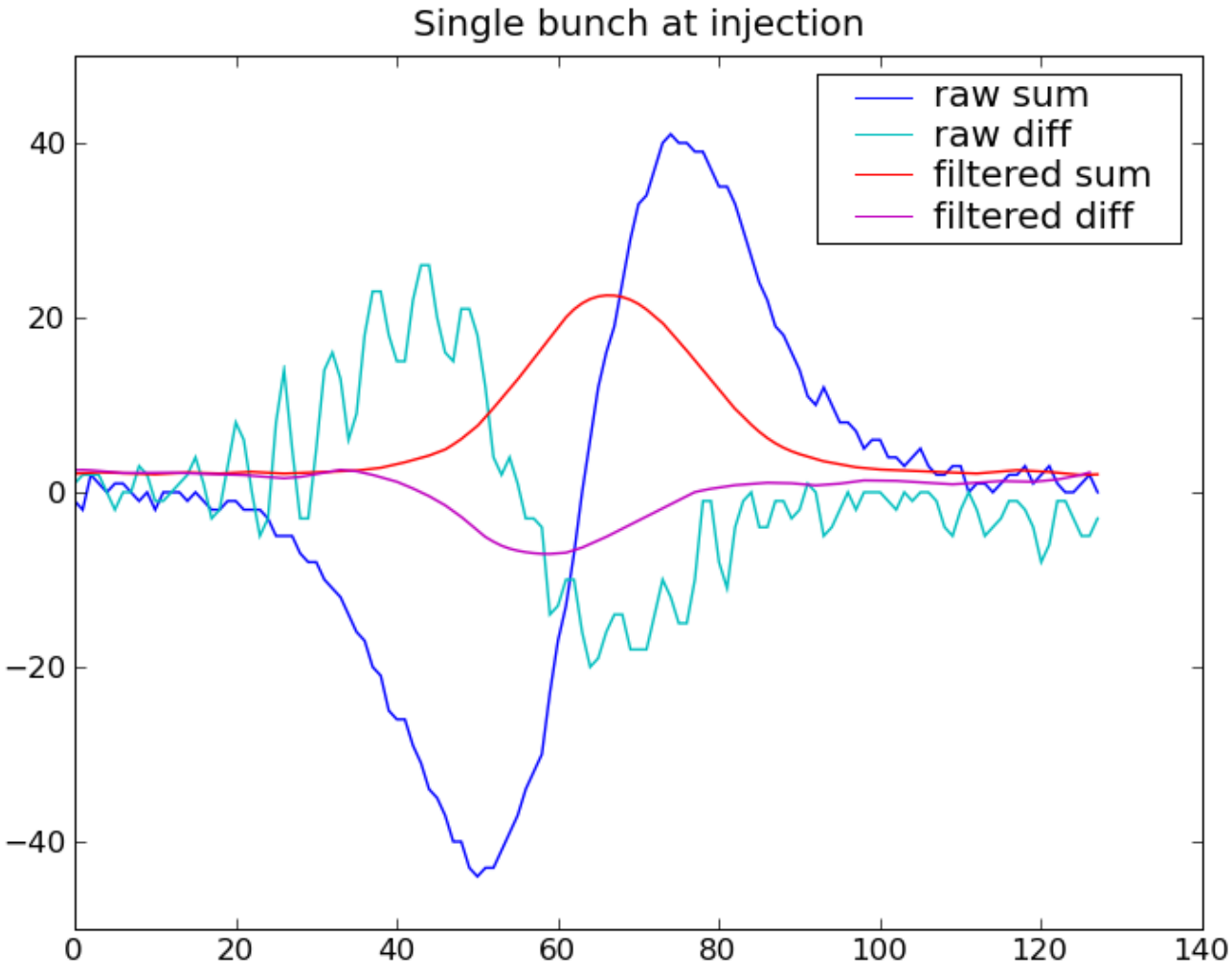
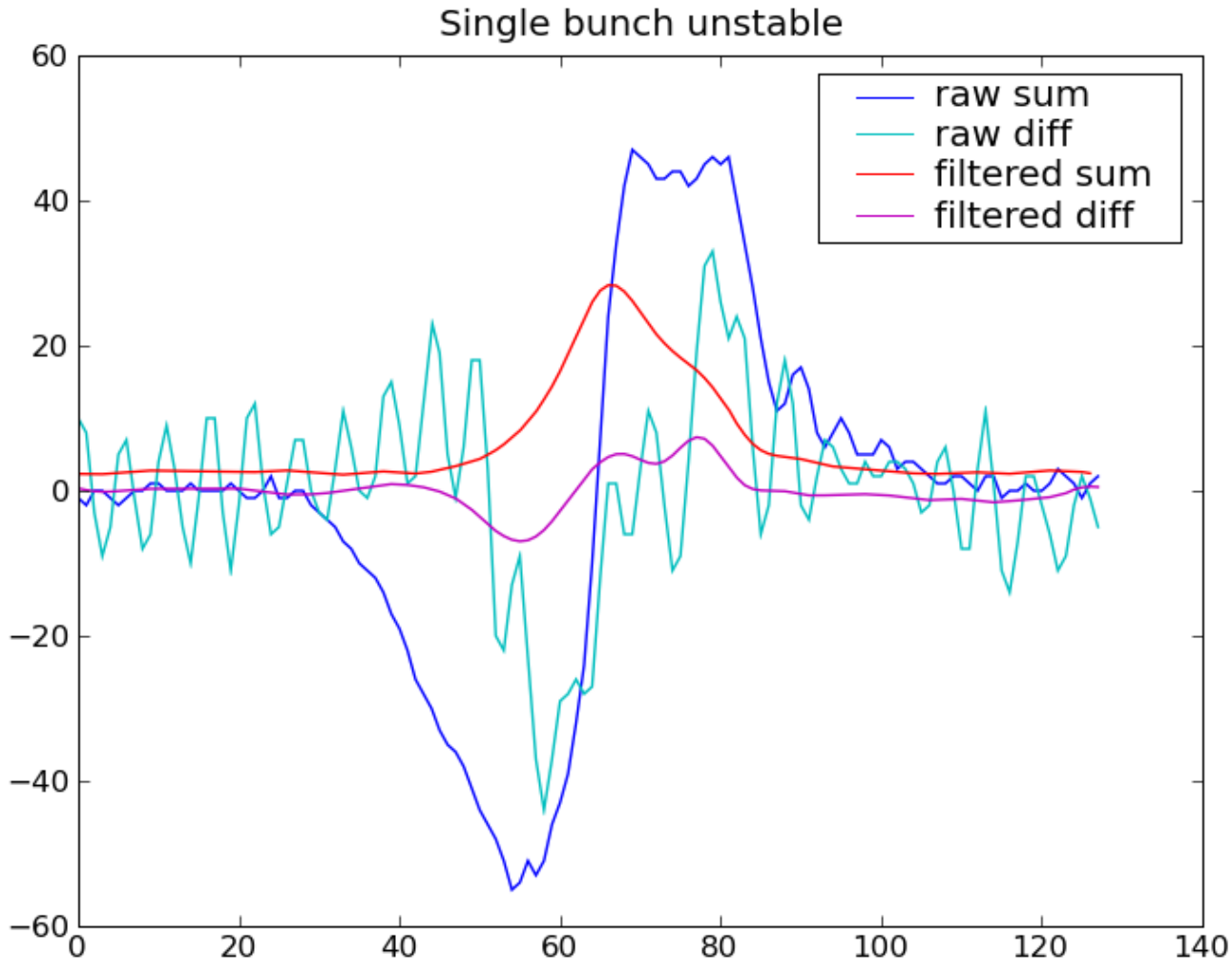


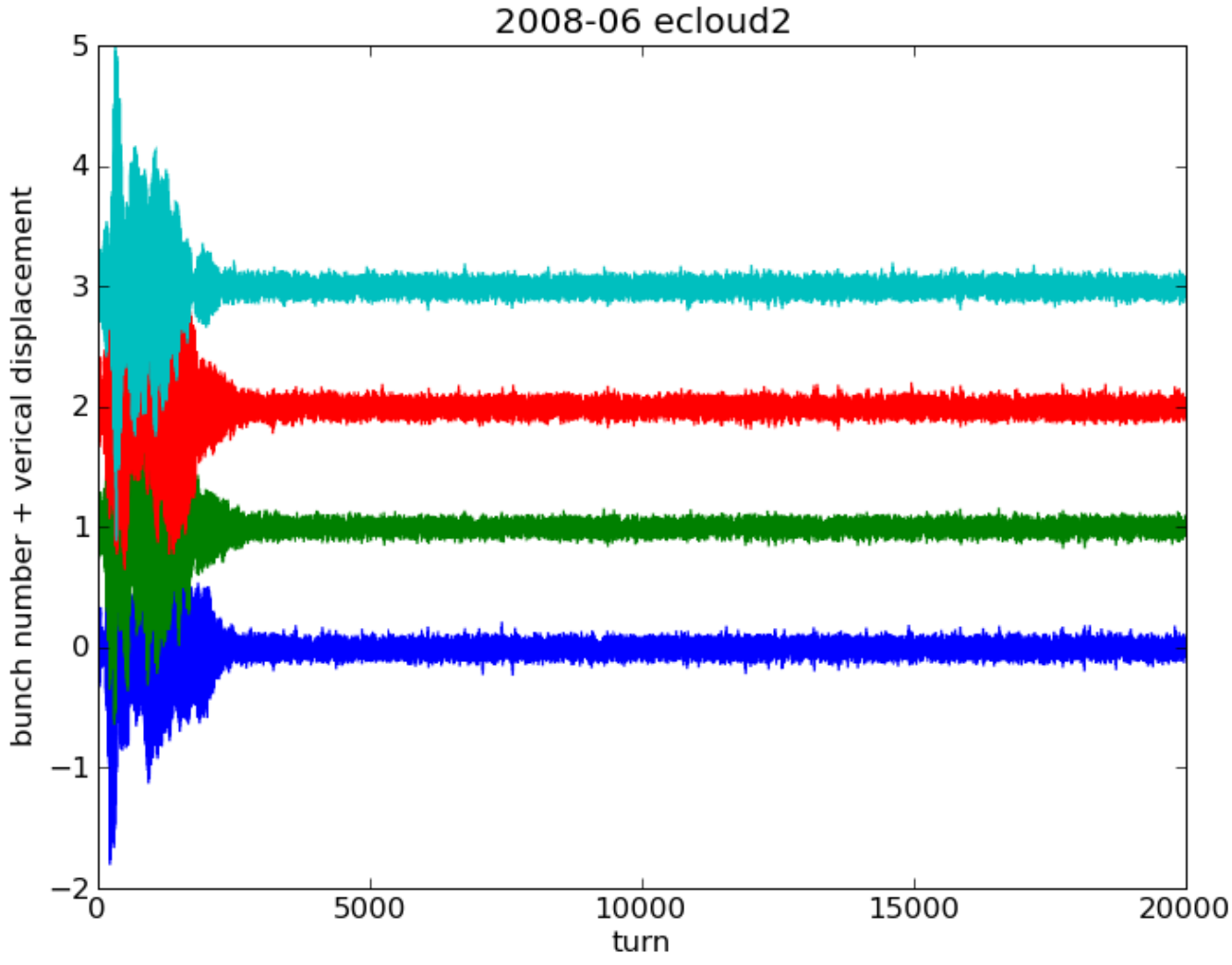
# Processing raw data



# One unstable bunches

movie

# Few unstable bunches



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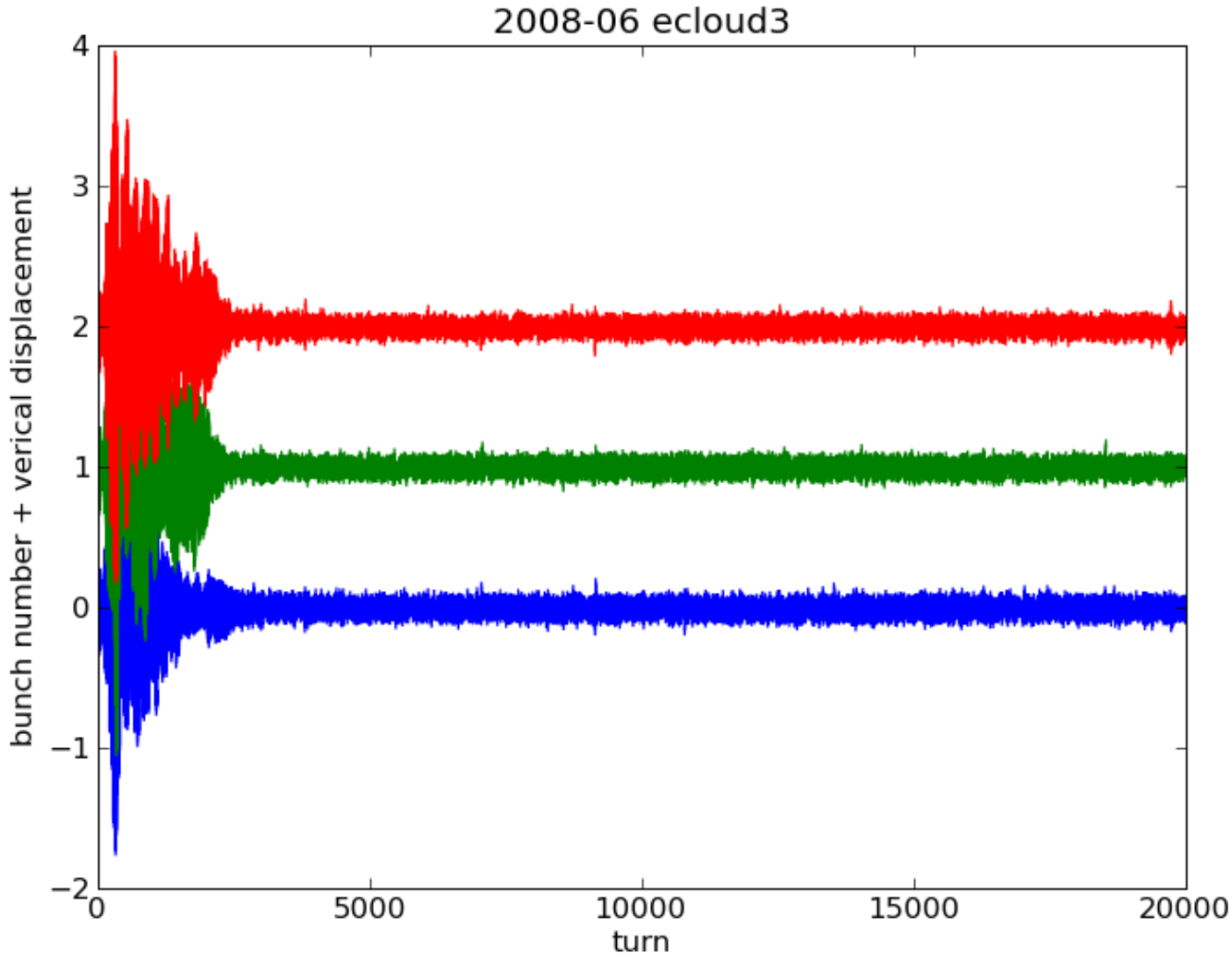

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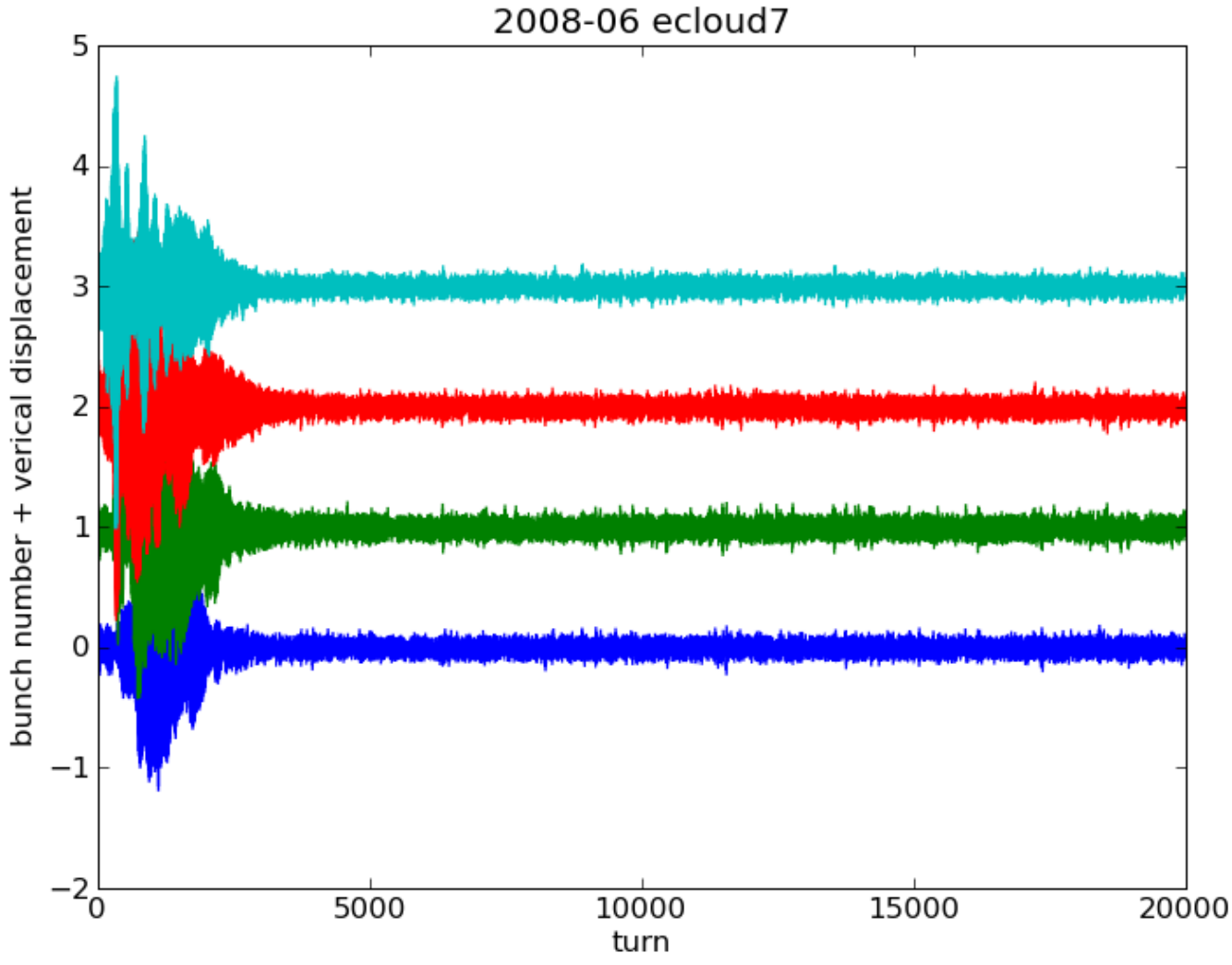

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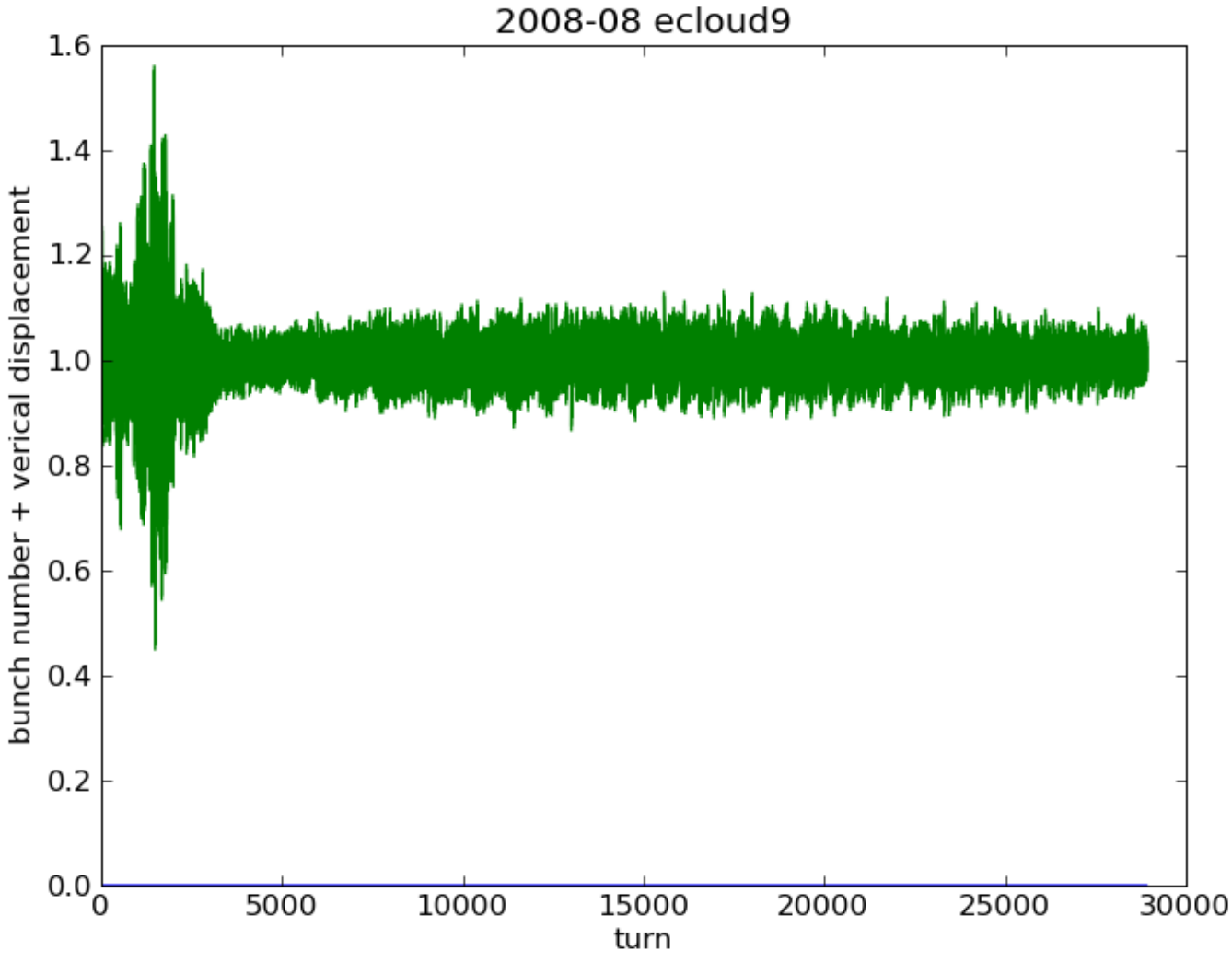
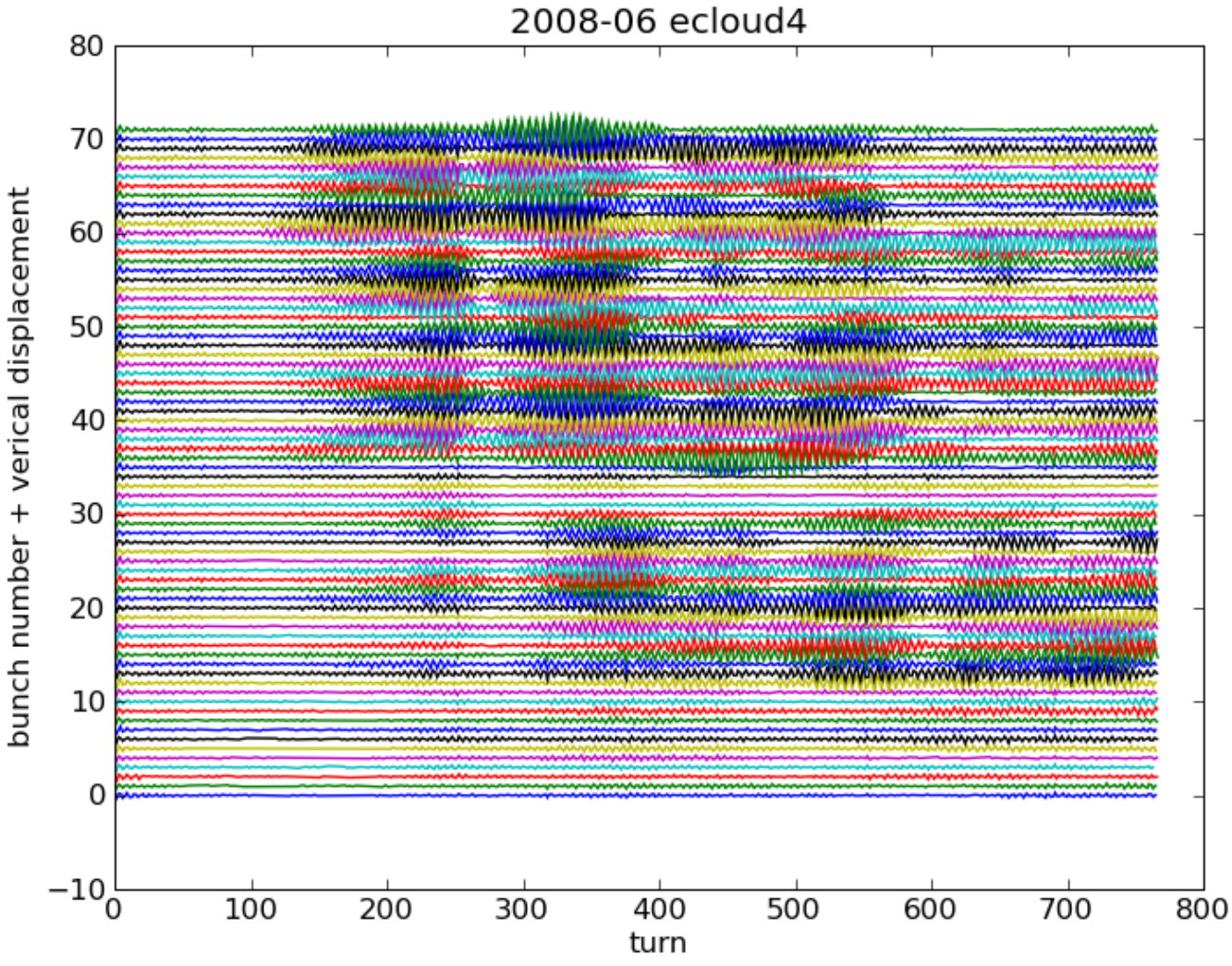
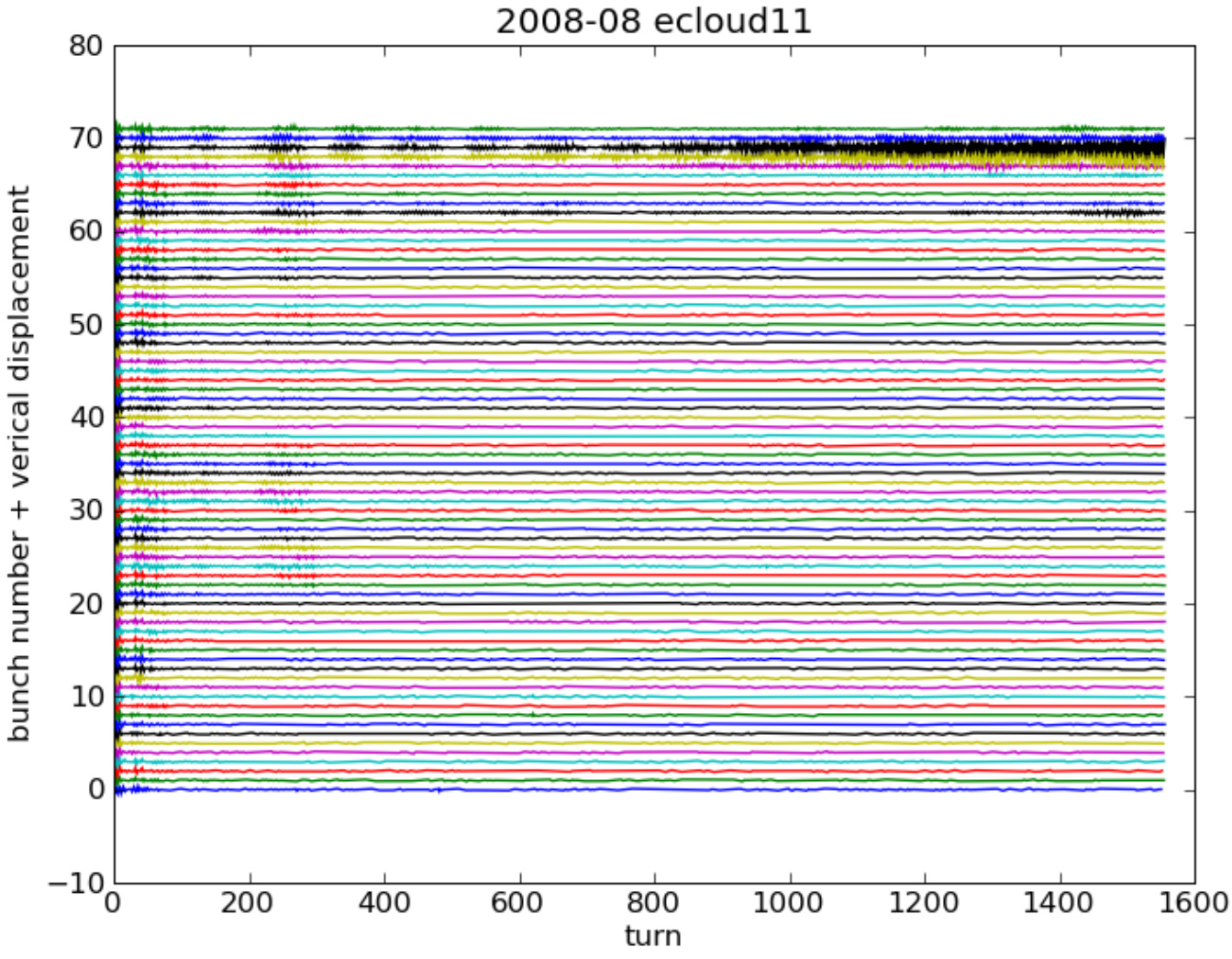


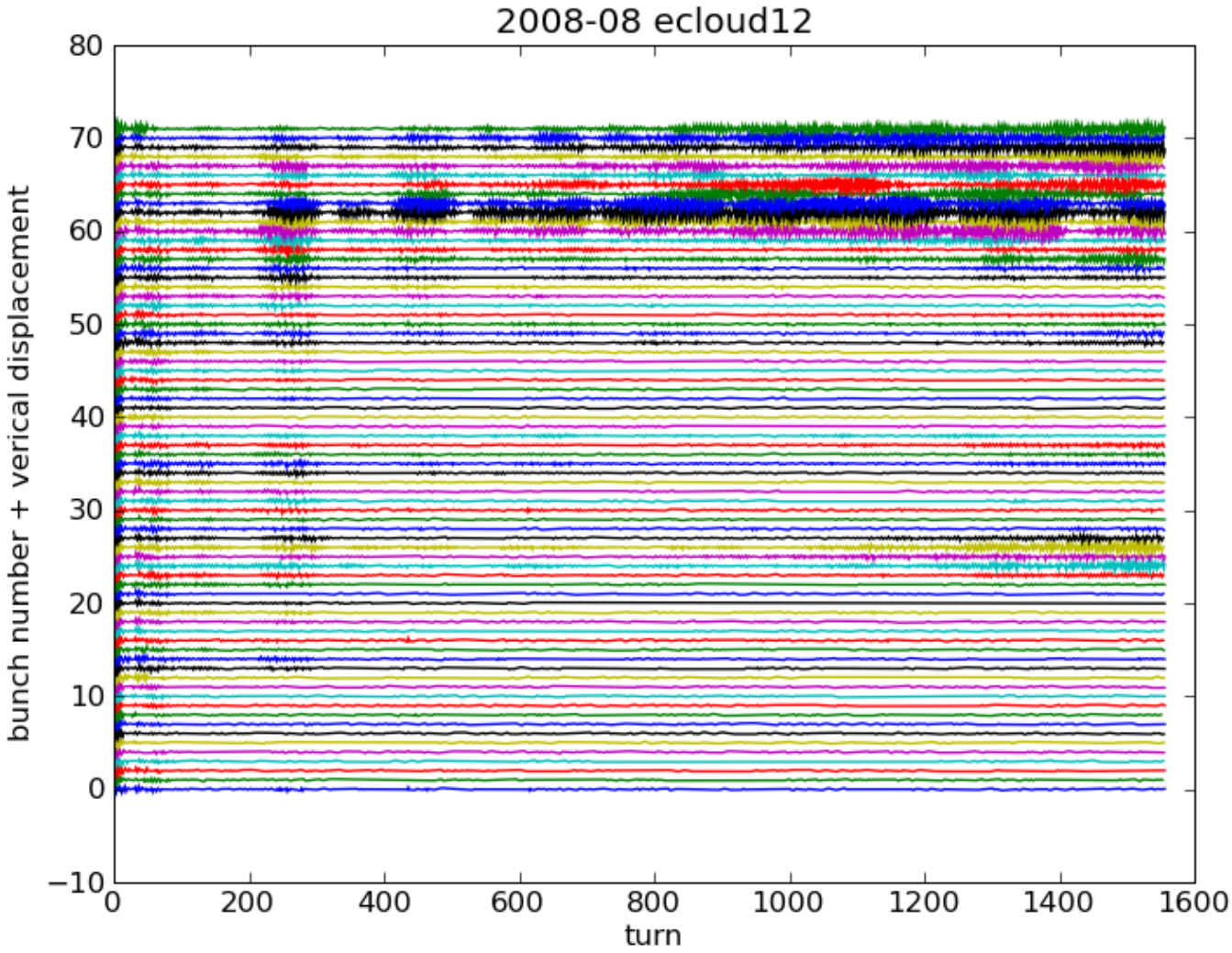
# Last batch


2008-06 ecloud4
bunch number + verical displacement
turn
80
70
60
50
40
30
20
10
0
−10
0
100
200
300
400
500
600
700
800

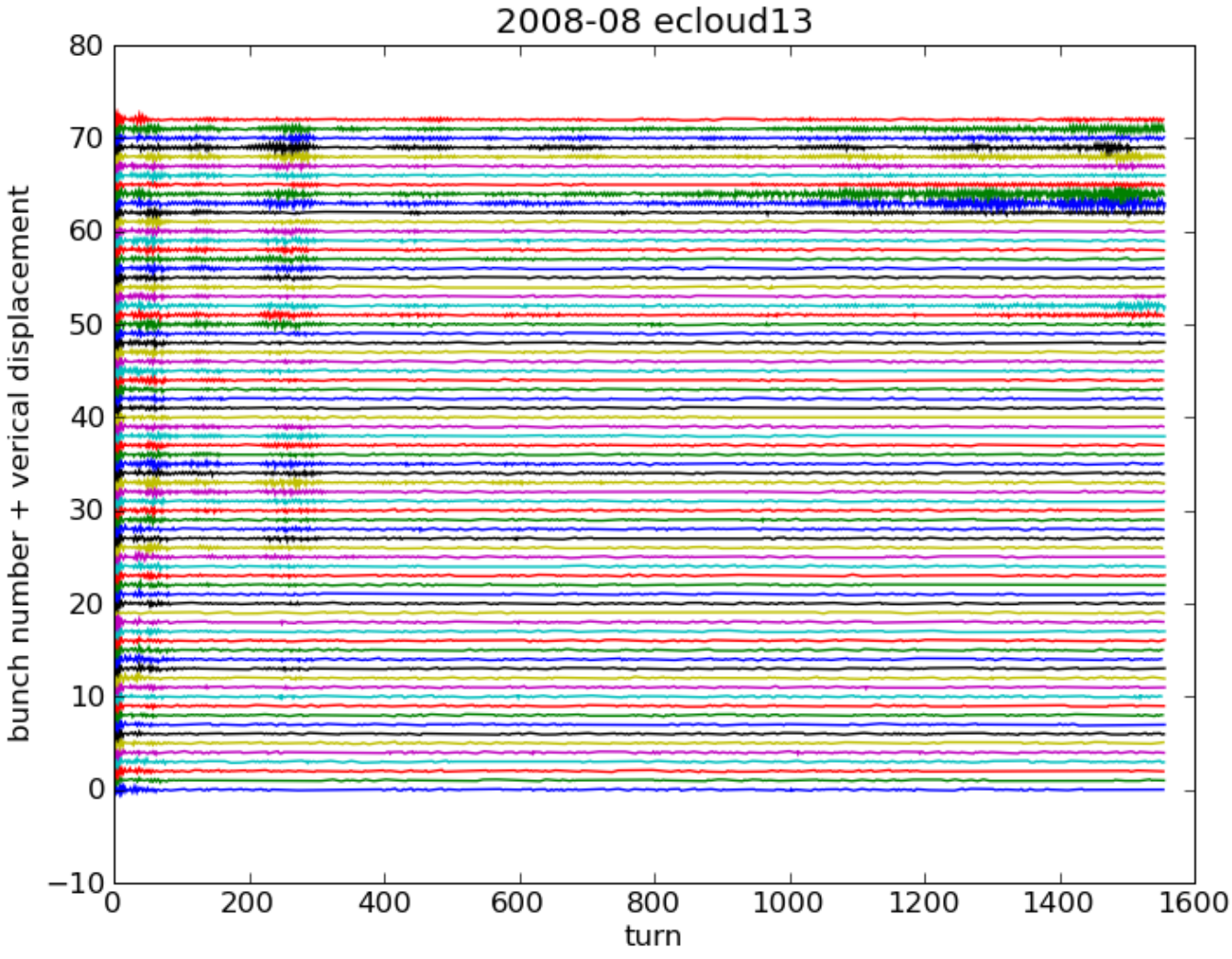
# Last batch


2008-08 ecloud11
bunch number + verical displacement
turn
80
70
60
50
40
30
20
10
0
−10
0
200
400
600
800
1000
1200
1400
1600

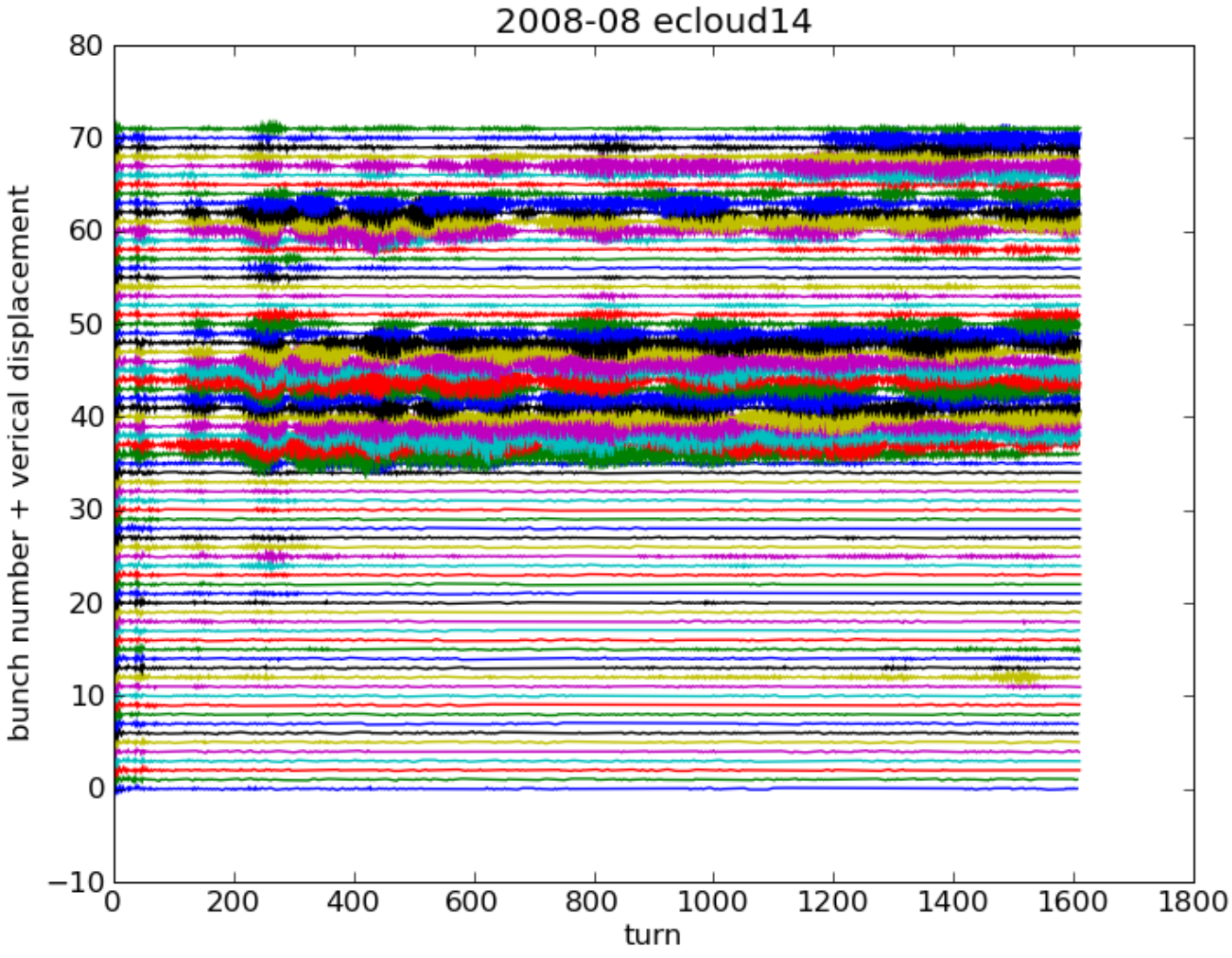
# Last batch


2008-08 ecloud12
bunch number + verical displacement
turn
80
70
60
50
40
30
20
10
0
−10
0
200
400
600
800
1000
1200
1400
1600

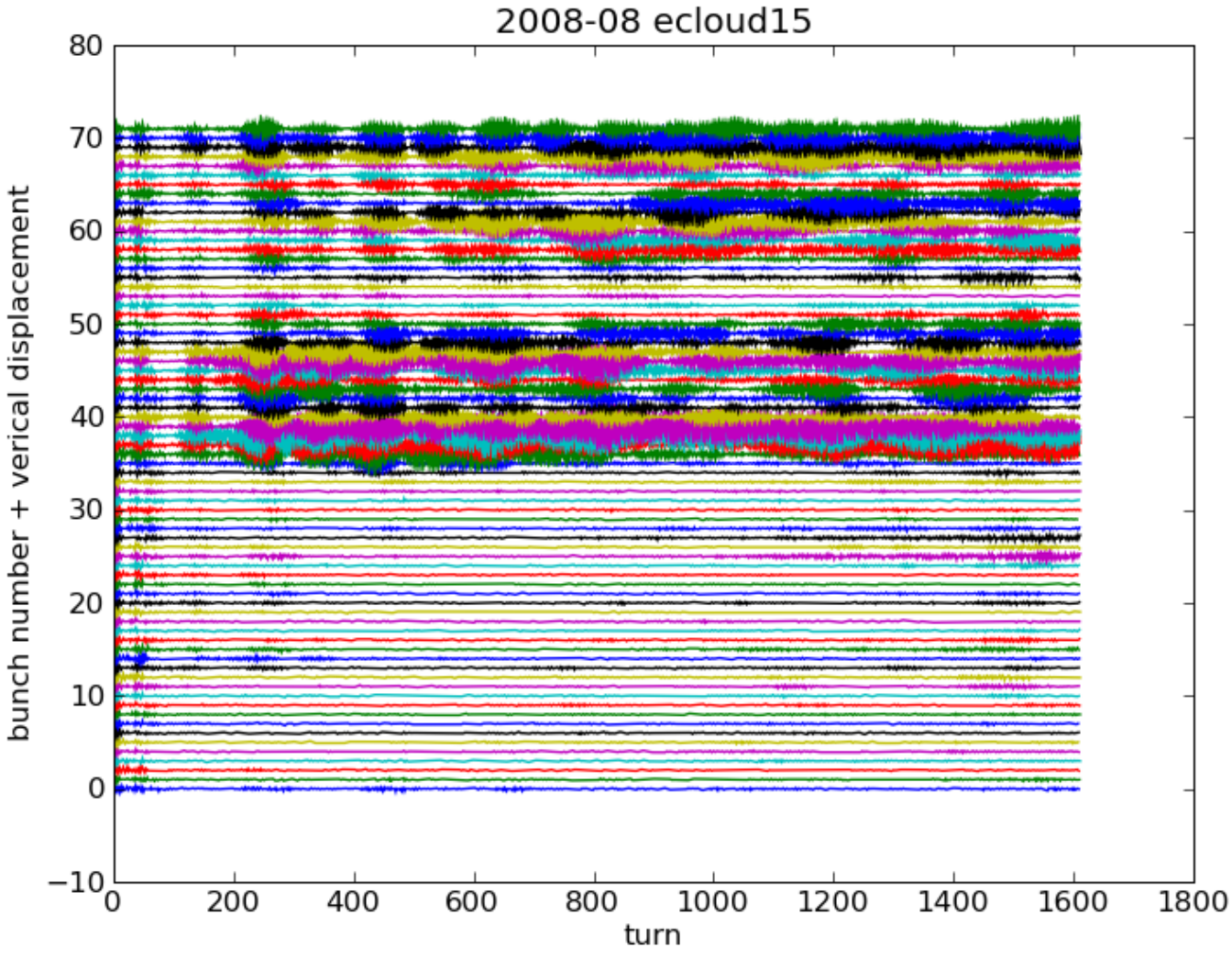
# Last batch


2008-08 ecloud13
bunch number + verical displacement
turn
80
70
60
50
40
30
20
10
0
−10
0
200
400
600
800
1000
1200
1400
1600

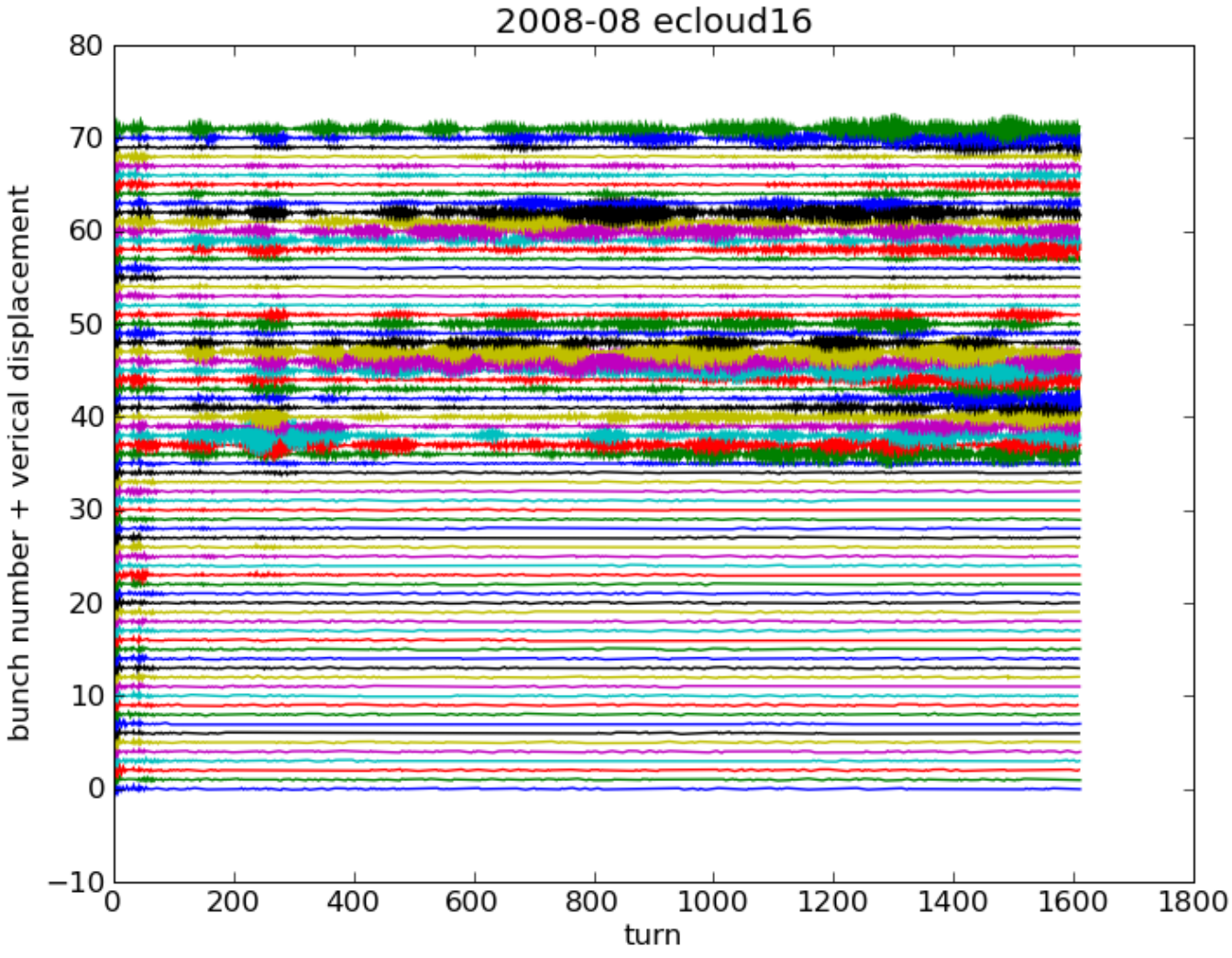
# Last batch


2008-08 ecloud14
bunch number + verical displacement
turn
80
70
60
50
40
30
20
10
0
−10
0
200
400
600
800
1000
1200
1400
1600
1800

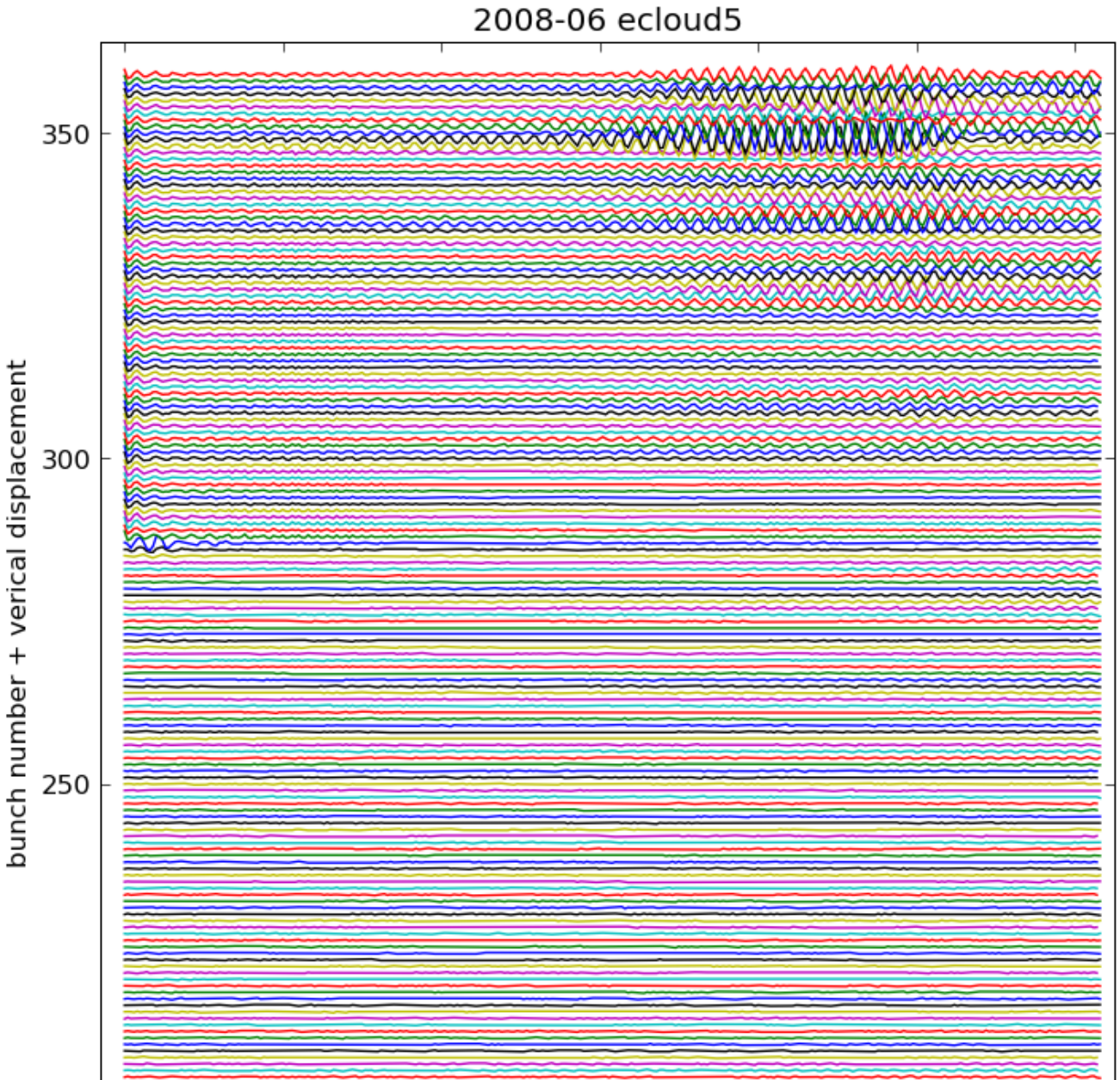
# Last batch


2008-08 ecloud15
bunch number + verical displacement
turn
80
70
60
50
40
30
20
10
0
−10
0
200
400
600
800
1000
1200
1400
1600
1800

# Last batch


2008-08 ecloud16
bunch number + verical displacement
turn
80
70
60
50
40
30
20
10
0
−10
0
200
400
600
800
1000
1200
1400
1600
1800

# Last batches



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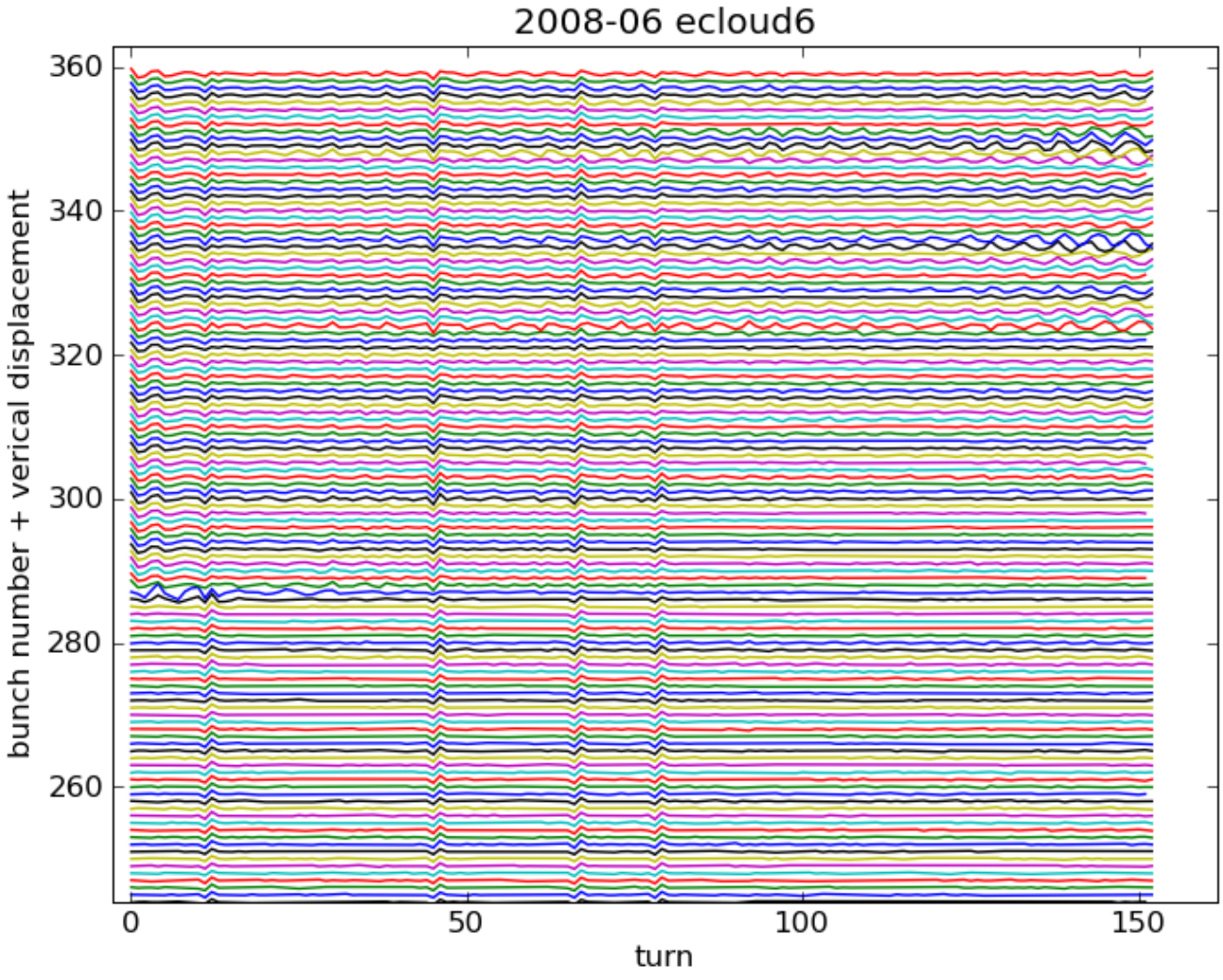

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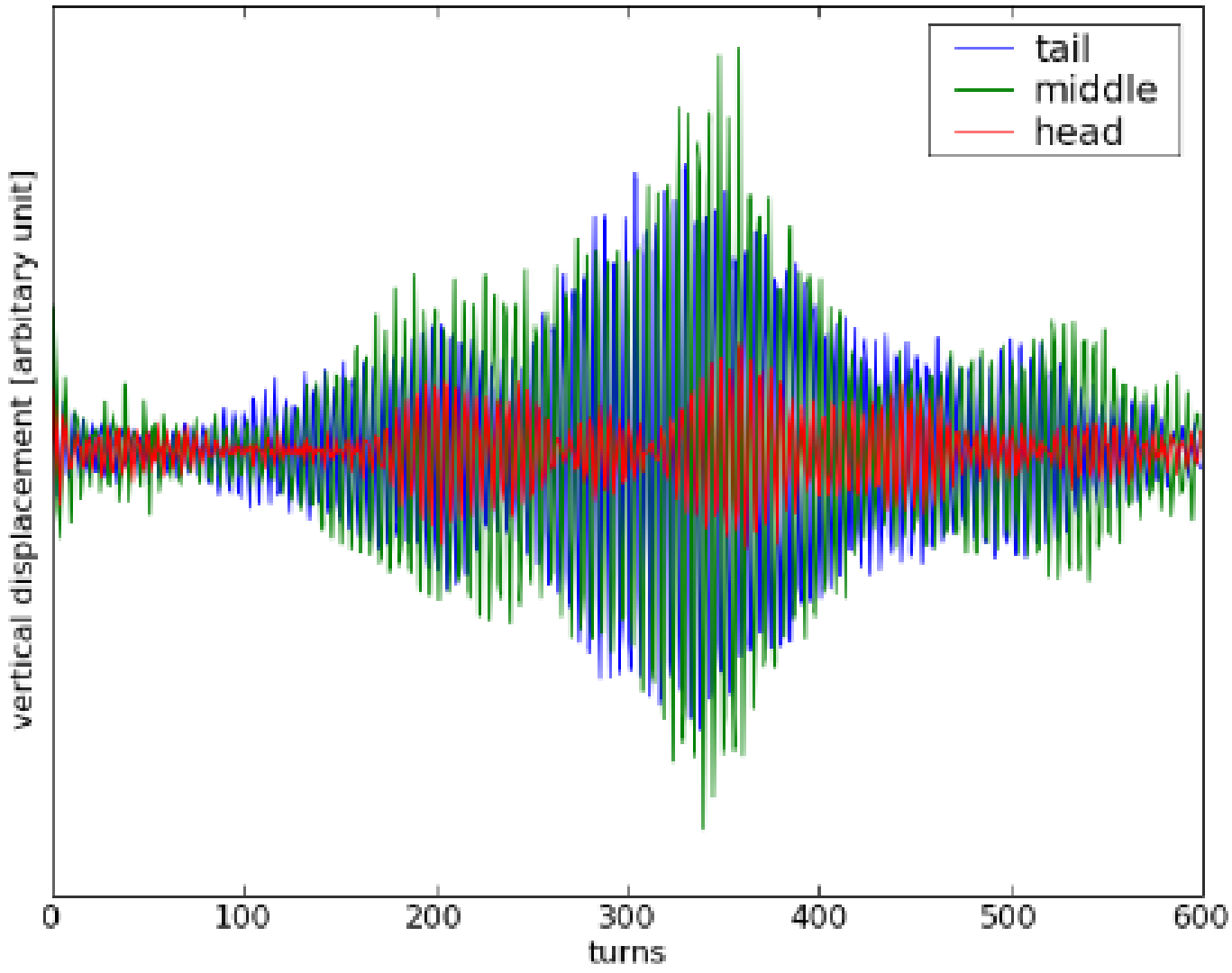

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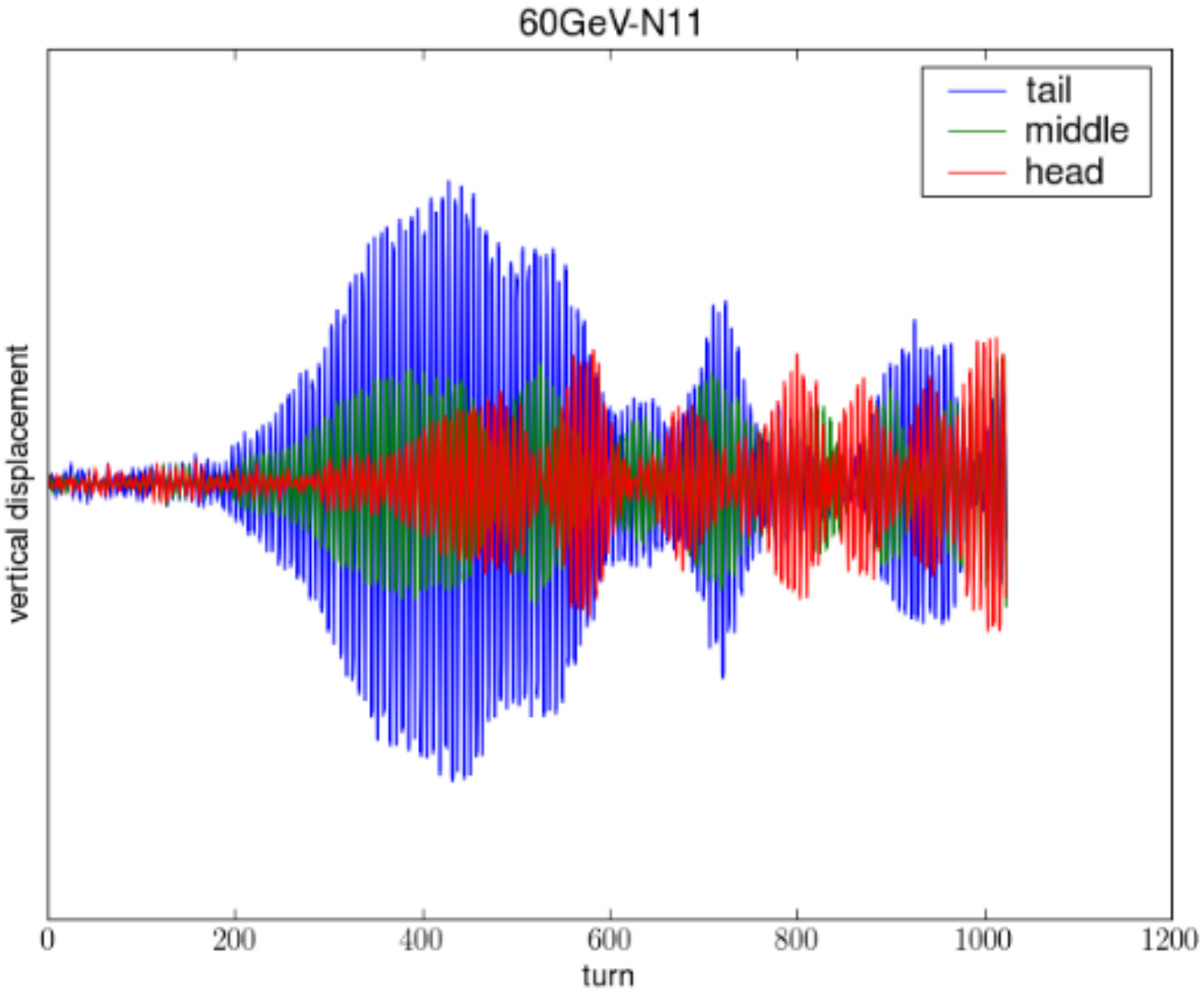

# Conclusion

- The measurements allowed a qualitative characterization of the instability.
- After injection oscillation, bunches in the last part of the last batch show a lower instability threshold compared to the one at the beginning.
- The bunch distortion are complex and they presents a large bandwidth frequency content (up to 1.5GHz).
- The rise time is in the order of 30-100 turns for fast instabilities.
- Comparison with simulation are encouraging.

# Future plans

- The measurements can be used to benchmark the simulation.
- To get more quantitative data, additional measurements are necessary.
- Simplified dynamic parameters can be extracted from the measurements and used as input for the feedback design.